United States
Department of
Agriculture

The Second RCA Appraisal

Soil, Water, and Related Resources on Nonfederal Land in the United States

Analysis of Condition and Trends

Soil and Water Resources
Conservation Act of 1977

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United States Department of Agriculture

June 1989

About This Report

This report describes the condition and trends of the soil and water resources and related resources on the nonfederal lands of the United States. Nonfederal lands are the 77 percent of the total surface area of the Nation owned by private citizens, by businesses and industries, and by States, counties, cities, and other units of nonfederal government.

The United States Department of Agriculture prepared this report in response to the requirements of the Resources Conservation Act of 1977 (RCA). This is the second report of the continuing appraisal required by that act, succeeding the first one published in 1981.

This report summarizes the results of many separate studies, inventories, evaluations, and analyses conducted by or for several USDA agencies over the past 5 years. Many of those studies are reported in more detail in other USDA publications. This document describes resource use, condition, and trends. USDA collects and studies information on other aspects of resource use and conservation as part of the RCA process. USDA's long-term plans for assisting agricultural producers to conserve their soil and water resources are described in the Program Report published in 1982 and the NCP Program Update report released in 1988. The results of evaluations of USDA programs for conservation of soil, water, and related resources are described in separate reports. Information about the condition of federal land is collected and published by the USDA Forest Service under the terms of the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA).

This document reports resource conditions as they were described in 1982. Possible effects of changed economic conditions since 1982 and of policies developed to address these new conditions are not reflected in descriptions of resource problems. For example, this document reports very little of the analysis USDA has conducted in planning implementation of the provisions of the conservation title of the Food Security Act of 1985. These provisions, enacted because the surplus of commodities and cropland was creating both economic stress and resource damage, provide for the protection of up to 45 million acres of highly erodible cropland in a 10-year conservation reserve, discourage the conversion of highly erodible land or wetlands to cropland, and encourage the use of conservation systems on highly erodible cropland after 1990. These new programs should significantly improve resource management and reduce some of the problems described in this report. To the degree possible, analysts did incorporate estimated effects of these new programs into their projections of future resource use and condition.

Most data on land resources in this report are based on the 1982 National Resources Inventory (NRI) conducted by USDA's Soil Conservation Service. For the NRI, data are collected for areas called major land resource areas, which are geographic areas with relatively homogeneous patterns of soil, climate, water resources, land use, and type of farming. These data are accessible by computer. For the appraisal, data were analysed at the major land resource area level using automated data processing methods. For presentation in this document, land data were aggregated to land resource regions (fig. a) or to multistate farming regions. All land data are shown by state in tables at the end of this document.

Some data are displayed as dot maps. These maps were generated by a computer program that uses the NRI data base and places the the proper number of dots in each county. The maps illustrate the general distribution of resources or concerns among states and within states but not the precise location within counties. The computer program does not take into account major land resource area boundaries or federal lands and, therefore, cannot precisely locate data within very large counties that include widely varying landforms and land uses or include large areas of federal land.

Data on water supply and water use were drawn from a number of inventories. Water data are shown for water resources regions, which are major watersheds, (fig. b) and for aggregated subareas, which are subdivisions of regions.

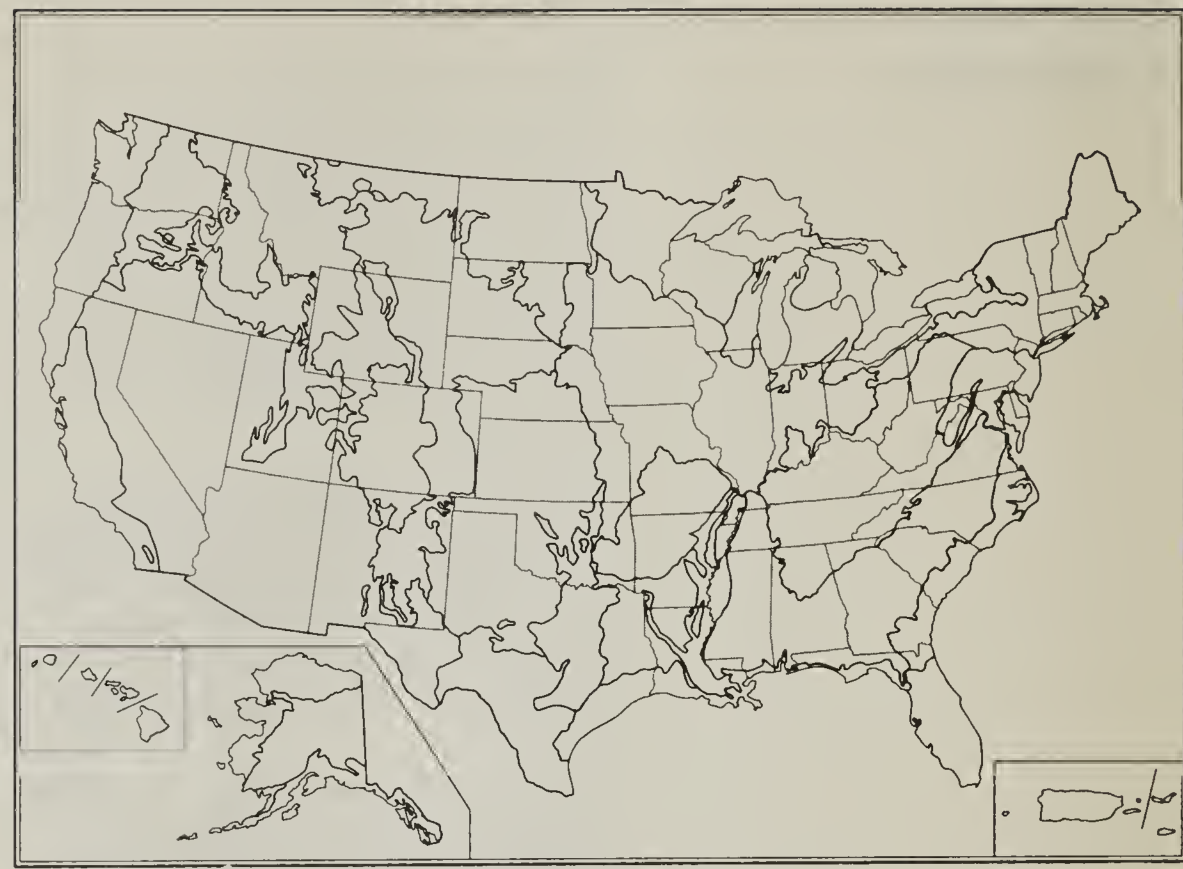


Figure a.--Land resource regions.

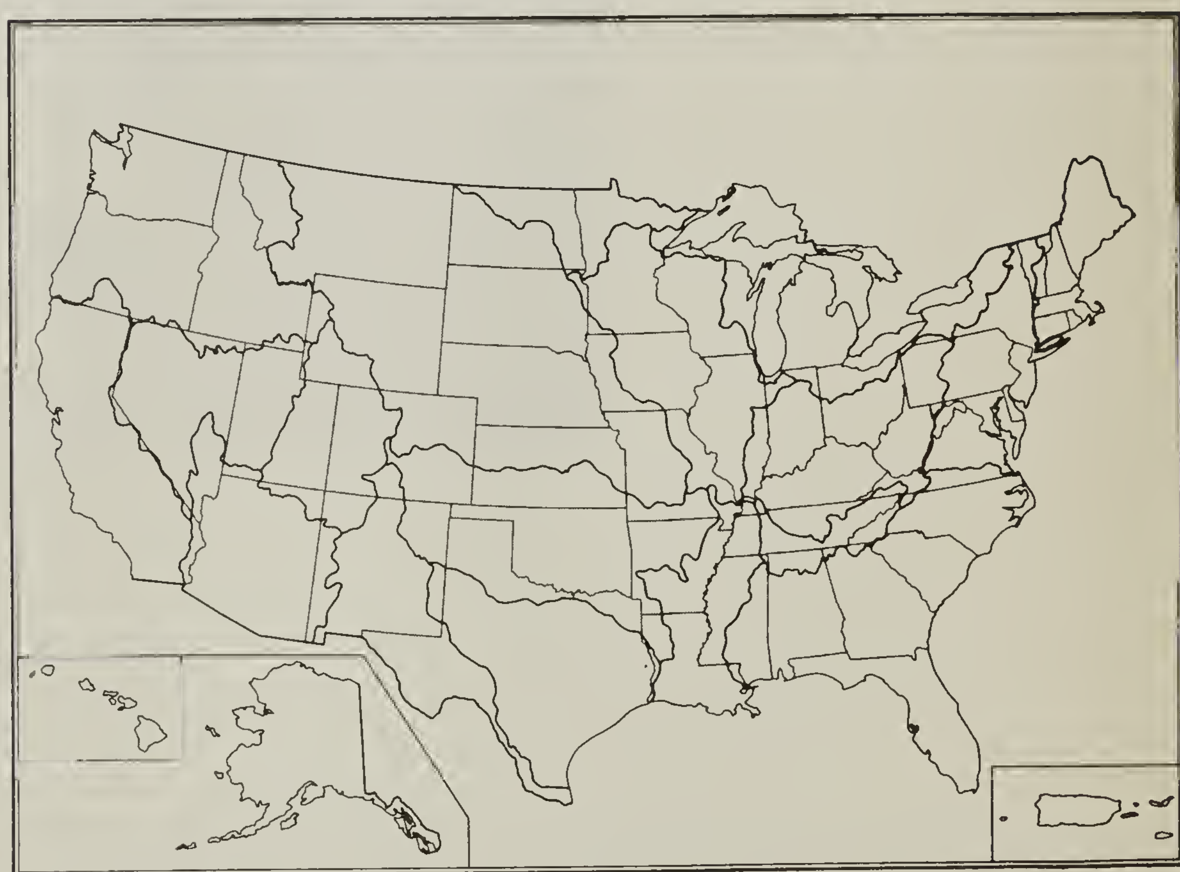


Figure b.--Water resource regions.

PREFACE
Natural Resources in a Global Context

This document reports the status, condition, and trends of the Nation's soil, water, and related resources on the nonfederal lands of the United States. Congress requires that USDA conduct a continuing appraisal to provide this information as a sound basis for current and future conservation policy and programs. In the future, however, wise use and conservation of resources will require more than resource data.

More than at any other time in history, agricultural production and related resource use in the United States are influenced by economic factors stemming from the agricultural and trade policies and activities of the world community. An understanding of the influence of the world community on U.S. agricultural production and resource use must antecede planning or policy development for conservation. Export sales represent a large part of the demand for farm commodities and therefore greatly affect prices and farm incomes. Equally important are the effects of international economics and of the policies of other countries on domestic factor and capital markets.

As information technology improves and as transaction costs continue to decline, the world economy will continue to have ever greater dominance over resource use and conservation. The influence of the global community fosters a resource-use environment that is not well controlled with the traditional domestic policy tools. The policies of other nations and general economic forces are outside the control of the U.S. agricultural sector and can only be affected by national and joint international policy and economic actions.

Current Agricultural Production Situation.--The most conspicuous aspects of the agricultural production situation of the early 1980's are the surpluses of commodities, depressed commodity prices, and reduced farm incomes. These conditions apply to our major crops, to dairy production, and to the cattle industry.

We have more land in crop and forage production than the markets call for. The situation is particularly difficult for those farm operators who have accumulated large debts and high interest costs along with reduced cash flow. There are no easy short-term answers to the problem of excess production capacity and depressed markets and prices. The Food Security Act of 1985 promises some transitional help.

Current U.S. Agricultural Export Situation.--Agricultural export demand, as the last few years have shown, is volatile through time, depending on global product, factor, and capital markets; world climate and weather patterns; international economies; and the policies of other countries.

During the 1970's, U.S. producers expanded production rapidly in response to sharply rising world food and fiber demands. It took 75 million acres more cropland in 1981 than in 1971 to meet export demands. That increase more than offset the 28 million-acre decline in land needed to meet domestic demands; a decline that resulted from improvements in agricultural productivity.

U.S. farm exports rose nine percent in value per year from 1971 to 1981. The rise was fueled by world economic growth, expansion of credit, new trade with previously closed economies, and a weak dollar.

Grain exports in the 1970's averaged over one-third of total production. Their rapid rise caused severe adjustment problems in the farm sector and stress on the resource base. In the 1980's, their rapid decline caused adjustment problems in resource use and stress on the farm sector.

In 1986, the value of farm exports was down 27 percent from peak levels and the volume was down 22 percent. The collapse in the export market followed a global recession in 1981 that strengthened the dollar, fostered trade barriers, and forced restructuring of Third World

debt (one condition being forced austerity and reduced Third World imports).

Compared to world demand, world supplies became more abundant. Just before that happened, however, the United States had raised price supports or loan rates for the major program commodities under the Agriculture and Food Act of 1981. That action was based on the expectation of continued growth in world food demands and U.S. exports as well as on the expectation of further rises in production costs due to inflation. When those expectations proved false, the U.S. share of the export market was reduced because other exporting nations lowered their prices below the U.S. loan rate. This reduced demands for U.S. exports.

The U.S. competitive situation was further weakened by the appreciation of the dollar compared to currencies of other countries.

At the same time, competition increased because of improved productivity abroad. This productivity resulted partly from Green Revolution technological advances and partly from agricultural policies offering price incentives and subsidies to farmers. Twenty-five countries had farm surpluses in 1984, including Finland, Indonesia, and Saudi Arabia. Eastern Europe has increased its production and reduced imports. The European Economic Community (EEC) has increased agricultural output per capita by more than 15 percent in the last decade and has shifted from the world's largest farm importer to the world's second ranking farm exporter. China is now more a competitor than a U.S. customer, particularly in Asian markets.

Domestic Policies of Other Countries.--Upon emergence, many Third World nations embarked on a program of rapid industrialization, often at the expense of their agricultural sectors. Petrochemical and manufacturing plants absorbed capital that could have been used for agricultural production, storage and transportation systems, research, and education. Additional capital paid for food imports, many of them from the United States. More recently, many countries have changed their policy as they realized that a healthy agricultural sector is often a precursor to economic development.

Wealthy nations, too, have designed policies to foster agricultural production. The motives seem to lie in the worldwide food shortage expectations of the seventies. Stronger policies for food production grew out of national security policy. For example, the State of Kuwait, alarmed by the Iraq-Iran war, embarked on a "food security" policy in the early eighties, seeking technology from USDA and other American and European consultants.

The EEC has developed policies resulting in overproduction and subsidized exports. The Soviet Union and Japan remain major food importers, but many other countries developed policies specifically to tap these markets. Among them are Australia, New Zealand, Argentina, South Korea, Thailand, and Indonesia.

Capital Markets.--Trading in money, credit, and capital among nations is on the order of 36 times greater than the exchange of goods and services worldwide. These transactions have a greater influence on domestic interest, savings, and investment than do exchange rates determined solely by trading in goods and services. The American agricultural sector, highly capitalized and indebted, is virtually without means to control these variables, yet must live in the financial environment created by them.

Another factor in the international capital arena is the federal deficit, which tends to keep interest rates high. The high interest rates attract foreign liquid funds, which in turn support the trade deficit. This is another area where there is little the U.S. agricultural sector can do, but the effects of higher interest rates are felt by highly indebted farmers.

The Long-Term Outlook for World Food Demands and U.S. Production. --For the world economy, the outlook to 2000 is for continued growth in population and improvement in overall productivity, resulting in increased disposable income per capita and increased demand for all commodities and services. Higher per capita incomes will induce shifts in some countries to more consumption of livestock products compared to crop products and will foster improved distribution of food to lower-income classes. This outlook suggests an increase of aggregate world food consumption of 2.0 to 2.5 percent a year. That rate of growth translates to a 30- to 40-percent increase in aggregate world food needs by 2000.

This bullish outlook for world agricultural commodity demands is accompanied by strong views among many experts that the resource base, technology improvements, social adjustments and policies of individual countries will develop in ways that will enable them to meet that demand with relative food abundance. Abundant supplies would result in generally declining prices for farm commodities in the world markets.

Other experts have expressed equally strong views that demands would grow faster than production and induce rising prices. In the past two decades, a great deal more was heard about this scenario for increased relative scarcity than is heard at present. Actual longer term world production performance and the current situation suggest that both extremes have low probability for the long run. A more probable outcome appears to be moderate increases in per capita and total food supplies, enough to bring some downward pressure on real prices received by farmers in the longer term. This outlook for the future indicates that reducing the direct costs of production needs to be a primary objective of all U.S. farmers who wish to participate in or find themselves dependent upon world markets.

Contents

List of Figures

List of Tables

Appendix B: Water Data

CHAPTER 1
Summary

The United States Department of Agriculture prepared this report in response to the requirements of the Soil and Water Resources Conservation Act of 1977 (RCA). Congress enacted this law because there was widespread concern about future food supplies and about environmental degradation.

The Act directs the Secretary of Agriculture to conduct a continuing appraisal of the soil, water, and related resources on the nonfederal land of the United States. The Act further directs that programs administered by the Secretary of Agriculture for the conservation of soil, water, and related resources be responsive to the long-term needs of the Nation, as determined by the appraisal. USDA issued the first RCA appraisal in 1981 and, after conducting extensive activities to determine the public's views about conservation, implemented the National Conservation Program based on that appraisal in 1982.

When the RCA was enacted in 1977, prices of agricultural commodities, exports of those commodities, and the acreage of cropland were increasing. U.S. grain stocks had been depleted since 1972. Famine was stalking many countries, and world resource degradation was accelerating. Adding to the concern was the perception that technology, which had provided continuous increases in agricultural productivity for decades, could not provide similar increases in the future.

In 1981, many of those trends sharply reversed. World demand fell in response to a worldwide recession and a serious debt problem in many importing countries. The increased productive capacity that had been developed in response to a decade of rising demand and prices piled up surpluses. New technologies, developed to avert shortages, seemed likely to perpetuate the "problem" of abundance.

Americans did not consider either the change in short-term economic conditions or the renewed optimism about the possible fruits of technology cause to abandon a commitment to fostering resource use that will serve the Nation's long-term interests. The Food Security Act of 1985 not only provided for new programs to take advantage of opportunities for improving resource management but, by requiring RCA appraisals in 1995 and in 2005, ensured that the information needed for wise management will continue to be available.

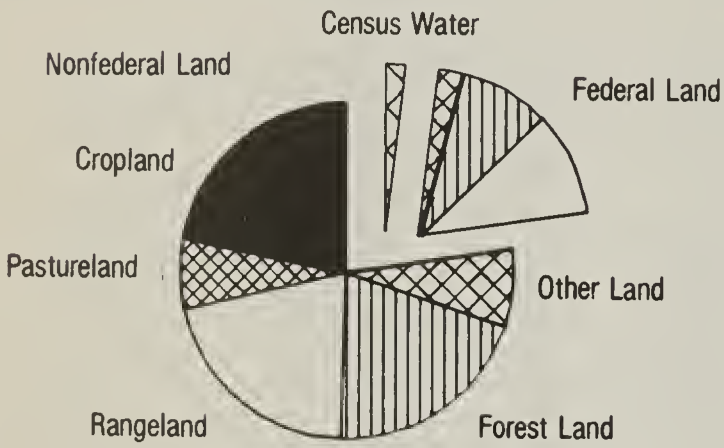
This second appraisal provides data on current resources and makes projections about future resource conditions, as did the first appraisal. The emphasis in the two is somewhat different, however. The first appraisal, conducted in response to increasing demand and the resulting resource degradation, sought to answer a single question: Will our resources be adequate to meet our long-term needs? The second appraisal, completed in a period when lower demand and commodity surpluses permit attention to goals other than maximizing production, asks whether we are making the best use of our resources, considering both immediate and long-term needs.

Analyses of current resource conditions address three broad questions relating to management of land and water for agricultural production and to maintenance of environmental quality as a whole. Analyses of future conditions project the results of a continuation of certain current trends and of two sets of changes in those trends.

The appraisal documents that our soil and water resources are both abundant and of high quality, and it shows that management of those resources is generally good. It also shows that there are problems. Degradation of some of our land resources continues, water demand and supply are not in balance, and processes intensified by agricultural production pose possible threats to environmental quality and public health.

The appraisal also shows that these problems can be reduced. Improved management, increased application of conservation measures, and better long-range planning of land and water resource use could improve current conditions and reduce the potential for problems in the future.

Land Use in the United States

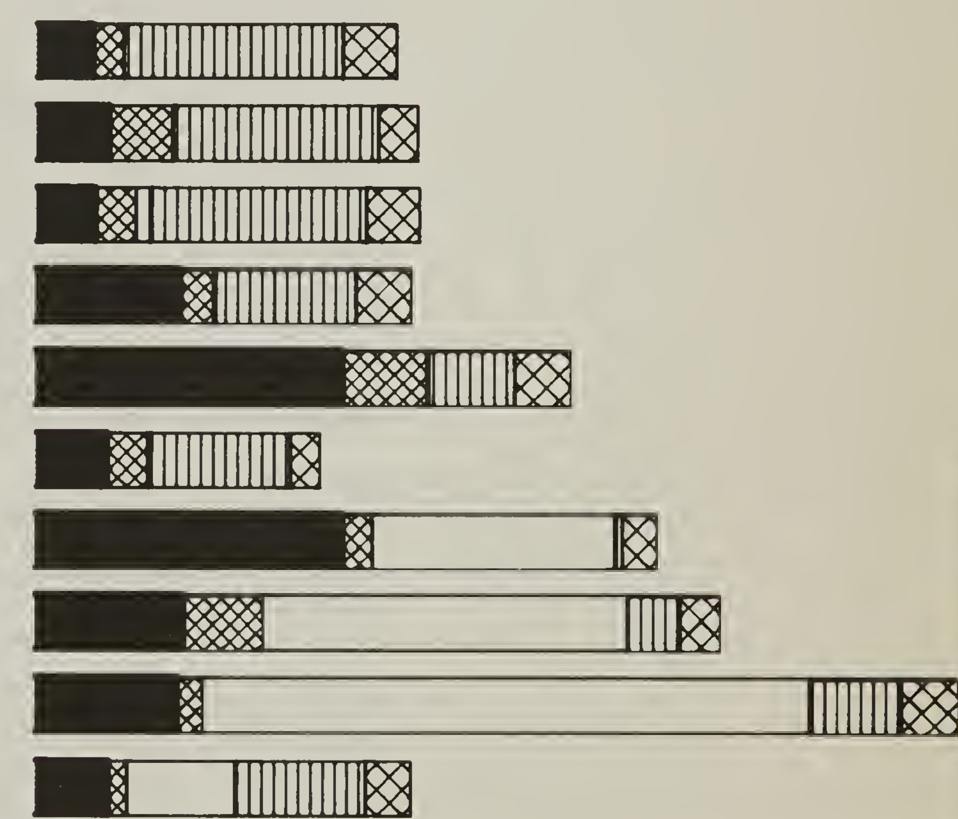


	Nonfederal	Federal
	(million acres)	
Northeast	109	3
Appalachia	116	8
Southeast	116	7
Lake States	114	8
Corn Belt	161	4
Delta States	86	6
Northern Plains	188	6
Southern Plains	208	4
Mountain States	280	262
Pacific States	114	90

Nonfederal Land

(million acres)

17	9	0	67	16	Northeast
23	18	0	62	12	Appalachian
18	12	4	66	16	Southeast
44	10	<1	43	17	Lake States
92	25	<1	26	17	Corn Belt
22	12	<1	42	9	Delta States
93	8	<4	2	11	Northern Plains
45	24	110	16	12	Southern Plains
43	7	184	27	18	Mountain
23	5	33	40	14	Pacific
421	133	406	394	142	Continental U.S.



Source: USDA-SCS, 1982 National Resources Inventory

Figure 1.--Use of nonfederal and Federal land in the United States.

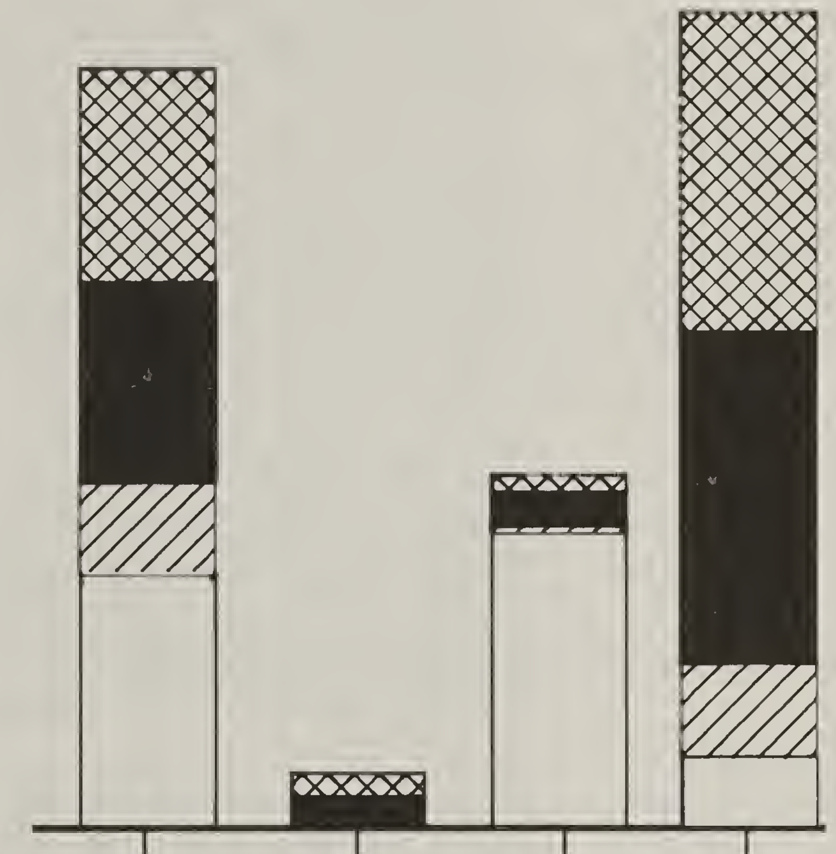
Land Resources: Capabilities and Limitations

The Soil and Water Resources Conservation Act requires that USDA appraise the capabilities and limitations of soil and water resources on the Nation's nonfederal land. The 1.49 billion acres of nonfederal land have the capability to meet our own needs and a high level of export demand, both now and in the future, if properly managed.

Good management of soil resources is based on understanding of the capabilities and limitations of the soil. Most of our agricultural soils are limited to some degree by inherent conditions that must be taken into account when the soils are used. Only 36 million acres are considered to have no significant limitations to use. The most widespread limitation is susceptibility to erosion. Smaller acreages are limited by characteristics of the soil's root zone, such as shallowness, stones, excessive salts or sodium, or low natural fertility. Others are flood-prone, have excessive wetness, or are limited by the severity of the climate.

Management that does not consider these limitations can result in eventual damage to soil and water resources. Under existing management, less than half of all agricultural land is adequately protected, according to the 1982 National Resources Inventory (NRI) conducted by USDA's Soil Conservation Service (fig. 2). "Adequately protected" means that soil erosion and other factors that limit sustained use are within acceptable limits. On cropland, the major need is protection against the hazard of erosion; about 49 percent of cropland was not fully protected against erosion in 1982. On much smaller acreages of cropland, erosion is not a serious risk, but improved management of water could conserve water and prevent degradation of soil and water quality through accumulation of excess salts, increase ease of management, protect soil tilth, or increase productivity.

Because perennial vegetation generally provides adequate protection against wind and water, erosion control is needed on relatively small acreages of pasture, range and forest land where the vegetation has been severely disturbed. On extensive acreages, however, changes in management could improve the condition of the perennial vegetation.



(million acres)	Adequately Protected	Treatment not Feasible	Treatment Needed: Erosion Control	Treatment Needed: Other
Forestland	146	17	12	218
Rangeland	136	19	25	226
Pastureland	61	1	6	65
Cropland	175	–	202	46

On adequately protected land, soil erosion and other factors that limit sustained productive use of the resources are within acceptable limits.

Treatment is not feasible on some land because a reasonable economic return is unlikely.

"Other" treatment needed includes measures to manage water and vegetation to conserve water, protect vegetation resources, and increase production of forage or timber.

Source: USDA–SCS, 1982 National Resources Inventory.

Figure 2.--Conservation treatment needs on nonfederal agricultural land, 1982.

Resource Status: Could It Be Improved?

Is the Productive Capacity of Our Land Being Maintained?

Although much of our agricultural land is well managed, the productive capacity of some agricultural land is threatened:

- About 1.5 million acres of agricultural land, most of them prime farmland, are irreversibly removed from production and converted to nonagricultural use each year.

- About 19 million acres of land used as cropland in 1982 are not suitable for cropping and are especially susceptible to loss of productivity.

- About 118 million acres of land used as cropland are highly erodible.

- Sheet and rill erosion or wind erosion exceeds the tolerable level on more than 173 million acres (40 percent) of cropland.

- A total of 48 million acres (9 percent) of cropland and pastureland are affected by excess soluble salts or adsorbed sodium.

- Nearly 12 million acres (9 percent) of pastureland are eroding excessively.

- Nearly 250 million acres (61 percent) of nonfederal rangeland are in less than good condition.

- Nearly 74 million acres (18 percent) of nonfederal rangeland are eroding excessively.

The following paragraphs summarize the severity and extent of problems on lands where improvement is possible and economically feasible.

Changes in Land Use Can Diminish Resource Productivity

A total of about 1.5 million acres of agricultural land, including about 96 million acres of cropland, are converted to nonagricultural uses annually. When agricultural land is converted to nonagricultural uses such as urban use, mining, or water storage, it is irreversibly removed from the agricultural base. Assuming the current rate of conversion continued, the cropland base would be reduced by nearly 48 million acres, or 12 percent, between 1982 and 2030, the period for which this appraisal projects resource conditions.

About 1 million of the acres currently being converted to nonagricultural uses each year are used for urban development. This is about half the rate at which land was converted to urban use during the 1970's. Even at the current rate, however, the Nation's urban land would double in 50 years.

The effects of conversion, not only on local and regional farm income and production patterns but on the Nation, may be understated if only the number of acres converted is considered. Much of the urban growth will occur on prime farmland in counties in or near metropolitan areas.

Much of the land available for conversion to cropland, should the need arise in the future, has lower capability as cropland than the land now in crops. Converting it to cropland would result in damage to the soil and to water quality, reduction in grazing land and forest land and, in some places, serious losses of wildlife habitat.

Erosion Is Reducing the Productivity of Some Soils

Soil erosion can reduce onsite capability of the soil to produce crops and can increase the costs of farming. In 1982, sheet and rill erosion moved more than 3.4 billion tons of soil on nonfederal rural land, and wind erosion moved 2 billion tons. More than 286 million acres of nonfederal land are eroding at excessive rates.

Although a permanent cover of grass or trees generally provides adequate protection against erosion, about 18 percent of our rangeland, 9 percent of our pastureland, and 6 percent of our forest land are eroding at rates above tolerance. Cropland is far more vulnerable to erosive forces--about 173 million acres, or 40 percent, of all cropland is eroding at rates of sheet and rill or wind erosion that exceed the tolerable rates. About 20 percent of cropland is eroding at two or more times the tolerable rate.

Sheet and rill erosion and wind erosion are not the only forms of erosion threatening agricultural land. Gully erosion and the concentrated-flow erosion called "ephemeral gully" erosion on cropland can also be highly destructive.

Soils differ in their sensitivity to erosion and therefore in the kind of management required to protect them from damage. Sheet and rill and wind erosion are not hazards on some soils; about 94 million acres of cropland have almost no susceptibility to damage by these forms of erosion. On 277 million acres of cropland, erosion is a hazard but damage can be prevented if resource management systems are used. On about 45 percent of that land, however, current management is permitting erosion to exceed tolerance. About 50 million acres of cropland are so highly susceptible to erosion damage that preventing damage is nearly impossible as long as the soils are used as cropland. If converted to grass or forest land, however, these soils would maintain their usefulness.

Salinization Is Damaging Some Soils

Salinization is a problem in arid and semiarid areas where precipitation is insufficient to leach salts from the soils. Saline or sodic (excessive sodium) conditions are lowering productivity on 9 percent of the Nation's cropland and pastureland, including more than one-fifth of irrigated cropland and pastureland. Seven western water resources regions have manifest salinity problems on 5 to 30 percent of their cropland and pastureland.

If the soil moisture around plant roots contains too much salt, most crops cannot absorb the water and nutrients they need to germinate and grow well. When soil salinity increases, the productivity of the land is reduced. Yields decrease, and farmers may be forced to switch to salt-tolerant crops or to abandon cropping altogether. Even low concentrations of some salts, such as selenium, are toxic to plants and animals.

Irrigating with saline water or poor management of irrigation water can cause salinization of irrigated land. Some cropping practices on nonirrigated land can cause saline seeps. Seeps occur where salt-bearing ground water accumulates at or near the soil surface.

Treatment of saline and sodic soils involves careful control of the salt balance. Efforts to deal with salinization must be planned to ensure that the problem is reduced, not just moved to another area. If farmers apply excessive amounts of irrigation water to leach salts and sodium from the soil, the salts and sodium lower the quality of water available to downstream water users. Water supplies may be rendered unfit for people or animals to drink and may cause high mortality of fish and other stream organisms.

Rangeland Resources Need Protection

There are more than 406 million acres of nonfederal rangeland. Between 1977 and 1982, there was little change in the total extent of nonfederal rangeland; in some states, however, there were significant changes. Extensive acreages in Montana, Colorado, and South Dakota were converted to cropland.

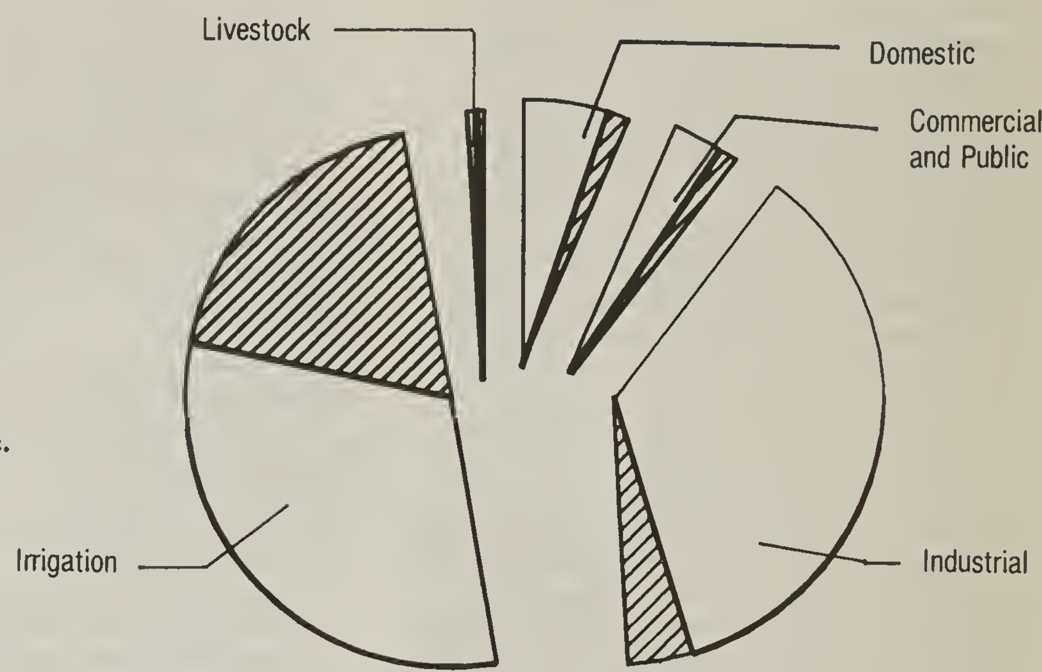
Range vegetation is an important renewable resource that is an integral part of the resource base. The health of rangeland and the potential for improvement through management are indicated by range condition. Much of our rangeland was severely damaged during the 19th century because people did not realize how fragile range ecosystems are. Range scientists report that rangeland has generally been improving in condition since the 1930's. In spite of that trend, 61 percent of nonfederal rangeland remains in less than good condition.

Approximately one-third of nonfederal rangeland was classified as adequately protected in 1982. On another one-third, improved management would improve range condition. The other one-third was in need of more drastic conservation treatment, such as brush management, range seeding, or erosion control.

Continued good management to maintain the improvement achieved so far is important because it is more costly to restore productivity than it is to maintain rangeland in good or excellent condition. Good management of rangeland increases forage for livestock, improves habitat for wildlife, and can increase the quality and quantity of the water supply that originates in rangeland watersheds.

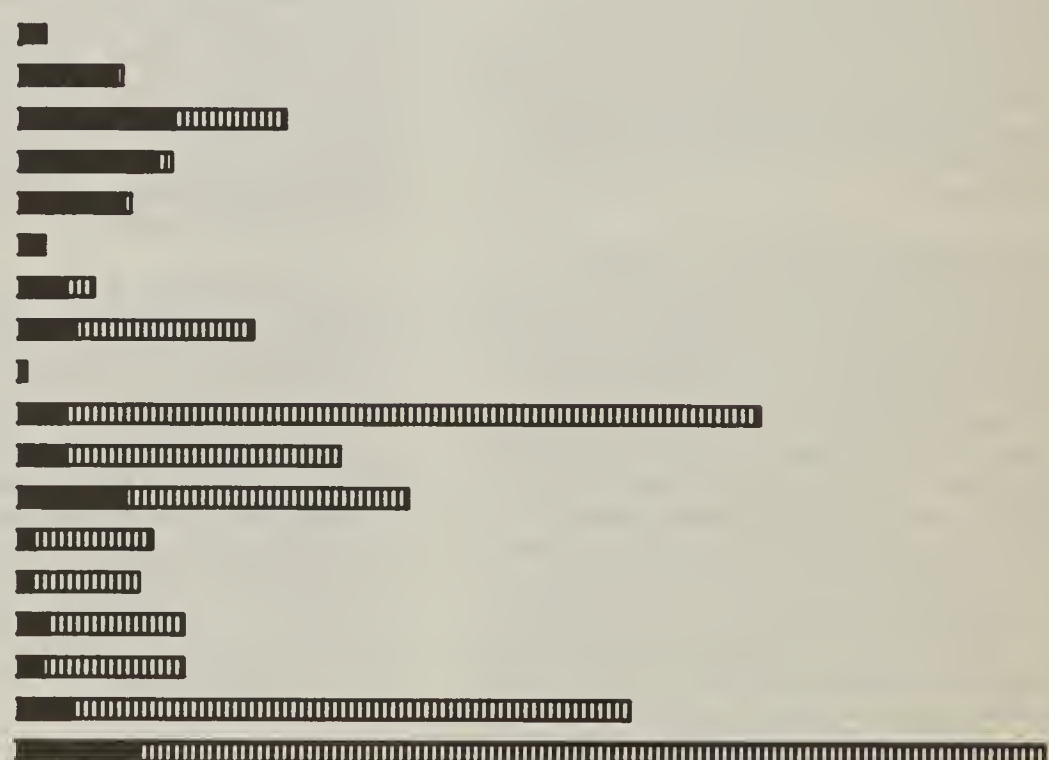
Water Withdrawal and Consumption in the United States, 1982

Withdrawals (billion gallons per day)	Consumption (billion gallons per day)	
21.1	5.8	Domestic
12.0	3.7	Commercial and Public
144.1	15.9	Industrial: steam, electric, minerals, manufacturing, etc.
128.4	78.0	Irrigation
2.2	1.9	Livestock



Water Consumption for Agricultural and Nonagricultural Uses

Nonagricultural (billion gallons per day)	Agricultural (billion gallons per day)	
0.6	<0.01	New England
2.1	0.2	Mid-Atlantic
3.4	2.6	South Atlantic
3.0	0.4	Great Lakes
2.3	0.2	Ohio
0.6	<0.01	Tennessee
1.1	0.6	Upper Mississippi
1.3	4.0	Lower Mississippi
0.1	0.1	Souris-Red-Rainy
1.1	15.3	Missouri
1.1	6.1	Arkansas-White-Red
2.4	6.3	Texas-Gulf
0.4	2.6	Rio Grande
0.3	2.4	Upper Colorado
0.7	3.0	Lower Colorado
0.6	3.1	Great Basin
1.2	12.4	Pacific-Northwest
2.7	20.0	California
25.0	79.3	Contiguous U.S.
0.1	0.0	Alaska
0.2	0.5	Hawaii
0.1	0.2	U.S. Caribbean
25.4	80.0	Nation



Source: Based on USGS Circular 1001

Figure 3.--Water withdrawal and consumption in the United States and use of water consumed, by region.

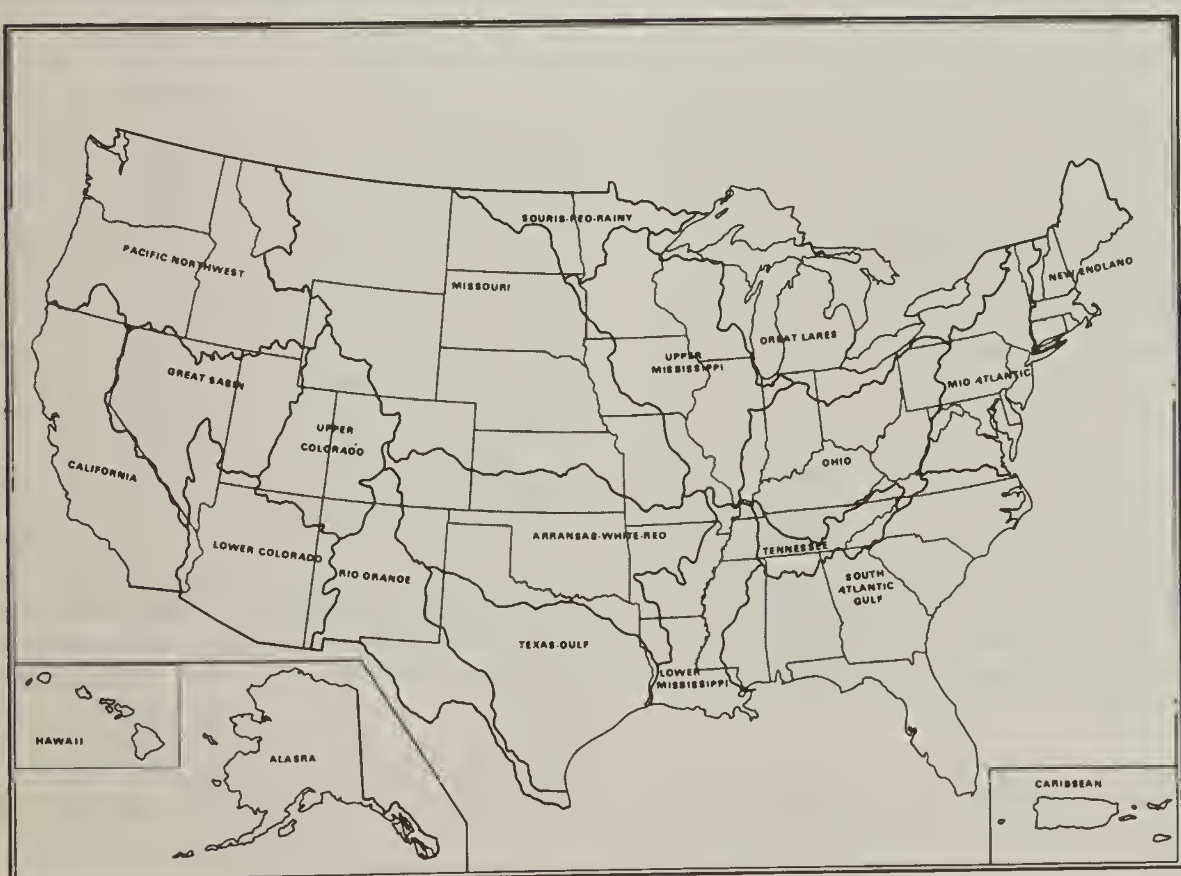
Are We Making Optimal Use of the Water Available for Agriculture?

Agriculture is a major user of water. It accounts for more than 40 percent of all freshwater withdrawn from surface or ground water supplies and for nearly 80 percent of the water consumed. (Not all water withdrawn for use is consumed.) In 1982, nearly 87 million acre-feet of water were consumed by irrigation on 49 million acres. The amount of water available to agriculture is decreasing because the amount used for other purposes is increasing.

o In 1983, 29 states reported temporary water shortages resulting from drought.

o Shortages are most common in arid regions, where crop production depends almost entirely on irrigation. Even in humid areas, however, droughts during the growing season are common and can significantly reduce yields.

o Ground water is being withdrawn at rates that exceed the natural recharge rate in many areas. Forty-seven States reported concerns about ground water supplies in 1983.



Many problems could be minimized with careful planning. Improved management of irrigation water, improved management of soil moisture, and increased storage to increase dependable supply can bring supply and demand into better balance.

Irrigation Water Can Be Used More Efficiently

Farmers have increased their efficiency in using irrigation water; a National average of 47 percent of the water withdrawn from surface or ground sources for irrigation was consumed by the crop in 1982 as opposed to 41 percent in 1975. Both off-farm and on-farm efficiency increased. In 1975, an average of 78 percent of the water withdrawn for irrigation reached the farm: in 1982 the average improved to 81 percent. In 1975, an average of 53 percent of the water delivered to the farm was used by the crop; this on-farm efficiency increased to nearly 59 percent in 1982.

In 1982, improvement of irrigation water management was still needed on 17 million acres--about 29 percent of all irrigated cropland and pastureland--to control erosion, reduce water losses, synchronize water applications with crop needs, or correct excessive saline or alkali soil conditions.

Better Management of Soil Moisture Can Make More Water Available to Crops

On nonirrigated land, especially in areas of limited rainfall, farmers can make more water available for their crop by increasing infiltration and reducing runoff. Use of practices for soil conservation/soil moisture management can reduce erosion and increase net returns.

Effective use of soil moisture conservation practices requires careful management and accurate soil information. Practices that increase retention of soil moisture in dry years also tend to retain water in wet years. Increases in movement of soil moisture to ground water may affect water quality if the water moves soluble nutrients and pesticides through the root zone into the ground water.

Increasing Storage Can Increase Dependable Supply

Dependable water supplies are quantities of water that users can rely on with a stated frequency of chance of shortage. Dependable supplies can be increased by storing high flows and runoff in reservoirs or aquifers. Ground water recharge beyond what would naturally occur is practiced in some areas to take advantage of the ground water storage.

Are Public Health and Our Environment Adequately Protected?

Managing our soil and water resources to serve the Nation's long-term interests requires appraising the effects of natural processes that either affect or are affected by agricultural production. Under current use and management of our soil and water resources, threats to public health and the environment have been identified:

o Floods cause about $5 billion in property damages each year.

o Erosion by water is estimated to cause between $3 and $13 billion in offsite damages annually. Erosion by wind causes offsite damages estimated to be of similar magnitude.

o Pollution of surface water by agricultural nonpoint sources has been reported in 44 states. Pollution of ground water by agricultural chemicals has also been documented.

o Above-normal levels of ozone in the surrounding air reduce crop yields, and atmospheric pollution is affecting forests and aquatic ecosystems in some areas.

o Wildlife habitat has been altered and, in many cases, severely degraded.

o A high percentage of wetlands have been lost.

Many of these conditions are not well-understood and data about them are preliminary and incomplete. New and better methods are being developed, however, to study these conditions, quantify the damages, and evaluate strategies for dealing with problems.

Upstream Flood Damages Are Increasing

Annual property damage caused by flooding is as high as $5 billion and is projected to rise to $9 billion by the year 2030 (1980 dollars). This is a faster rate of increase than was projected just 5 years ago. This estimate does not take into account the lives lost and the physical and mental trauma caused by floods. Damages in upstream watersheds account for half of all flood damages, and 80 percent of upstream damages occur in rural areas.

About 14 percent of the Nation's cropland is on flood-prone lands. Flood-prone lands will likely remain in agricultural use, both because of their high productive capacity and because costs of capital improvements, insurance, and related factors will discourage their conversion to other uses.

Agricultural damages are expected to increase in the future because cropland is being cropped more intensively, requiring larger investments. Damages to cropland and pasture, however, will not increase as rapidly as damages in urban areas and damages to land in other rural uses.

Atmospheric Deposition Is Causing Popular Concern

This appraisal reviews findings of studies of the effects of acid deposition and of ozone on crops, forests, soils used for agricultural purposes, and surface water. It does not include data on potential agricultural contributions to atmospheric deposition such as pesticide drift or acid fog.

Acid deposition contributes to acidity in lakes and is suspected as a causative factor in the decline of productivity of forests in the eastern United States. Acid deposition has not been documented to cause damage to cropland.

The presence of above-normal levels of ozone in the surrounding air does injure plants and decrease crop yields. Ozone has been estimated to decrease agricultural production by 5 percent annually.

Offsite Damages Caused by Erosion and Runoff are High

Water erosion and runoff from agricultural land cost the Nation between $3 billion and $13 billion (1980 dollars) annually. Wind erosion imposes additional costs. These costs result from damage to water, land, and air quality.

Erosion and runoff from agricultural land reduce water quality in streams, reservoirs, and lakes. Major nonpoint source pollutants in surface waters are suspended particles of solid material, nutrients, waste-related bacteria, pesticides, and dissolved salts. Water infiltrating agricultural lands can carry soluble nutrients and chemicals into ground water.

Sedimentation decreases water storage capacity in lakes and reservoirs, clogs streams and drainage channels, causes deterioration of aquatic habitat, damages water distribution systems, and decreases cropland productivity. Sixty percent of all sediment delivered to the Nation's waters is from agricultural lands.

Blowing soil resulting from wind erosion lowers air quality. It aggravates respiratory ailments in humans and animals, reduces visibility for drivers and airplane pilots, clogs machinery and filters, and permeates homes and workplaces. When dust covers plants, it inhibits photosynthesis, and the quality of crops is reduced. Wind erosion also damages plants by sandblasting and by defoliation.

o Potential sources of agricultural nonpoint source pollution.--Pollution from nonpoint sources is reported to be the major remaining cause of reduced water quality in 6 of the 10 EPA regions, and agricultural activities are the most pervasive nonpoint sources in

all regions. For this appraisal, USDA estimated the potential for agricultural nonpoint source pollution in the Nation's watersheds. The pollutants assessed are pesticides, nutrients, animal wastes, sediment, and salinity.

Identifying potential for pollution problems is necessary because agricultural nonpoint source pollution is generated by widespread land use activities and is conveyed to waterways through natural processes such as storm runoff or ground water seepage rather than by deliberate, controllable discharge. Monitoring the entire rural countryside for agricultural nonpoint sources of pollution is not practical or affordable.

The effect that reducing erosion might have on water quality has been analyzed using a national water network model. The analysis suggests that, for some contaminants, controlling cropland erosion would improve water quality significantly in many areas in the East and Midwest but that, in the West, erosion would have to be controlled on other land as well as cropland. Improving quality in some areas would not be possible unless erosion were controlled in upstream watersheds where erosion control is not needed to improve local water quality or would not improve local water quality enough to meet the recommended standard.

o **Costs** of **offsite** damage of **erosion**.--Methods to precisely estimate all types of offsite damages have not been developed. Costs of sediment and associated chemicals moved offsite by water erosion have been described as instream and offstream damages. Best estimates are that sediment and sediment-associated contaminants cause damages of more than $4 billion annually (not including damage to aquatic habitat) when they are suspended or deposited in waterways. Offstream damages are estimated to be almost $2 billion. Wind erosion damages likely are similar to water erosion damages in magnitude.

Water erosion and runoff from cropland are estimated to cause about one-third of total offsite damages, about $2 billion annually. This amount is higher than the cost of the permanent damage to cropland soils that erosion causes in any single year.

Estimates of onsite and offsite damages are not entirely comparable, however. The offsite estimate includes both long-term damage and short-term damage; the onsite estimate includes only long-term costs. Much of the short-term damage could be corrected if the erosion were prevented. The long-term loss of productivity caused by erosion is permanent and cumulative.

o Ground water contamination.--In 1984 reports to EPA, 35 states reported some problems with contamiNation of ground water. The most commonly reported sources of contamination are industrial and municipal. Ground water contamination from use of pesticides and nutrients in agricultural operations is also being reported. Many states have only limited information about pesticides and nutrients in ground water. Numerous efforts are underway to collect more data to identify current problems and determine the potential for future contamination.

o **Damage** to aquatic habitat.--Although most of the Nation's streams provide suitable habitat for some aquatic species, various factors are reducing the quality of the habitat for more than four-fifths of the Nation's fish communities. Agricultural nonpoint sources of pollution are reducing water quality in 29 percent of all streams. Agricultural diversions, primarily for irrigation, are reducing water quantity enough to damage habitat in 14 percent of streams.

Wildlife Habitat Has Been Altered

For this appraisal, USDA analyzed habitat characteristics, not wildlife populations. When people use land for agriculture, they can change the quantity and quality of the habitat the land provides for wildlife and, therefore, the number and species of animals that can live there. The habitat can be considered a "structure" composed of one or more of seven layers of vegetation. The diversity of the structure of the existing habitat can be compared to that of the natural vegetation of the site. The structure of the habitat has been changed to the greatest degree in the regions where we use the land most intensively. Wildlife habitat in the Midwest has less than one-third of the structural diversity that it had before people began to use the land. In some other parts of the Nation, the land still provides habitat not greatly changed from its natural state. The value of the layers as habitat is affected by, and therefore can be improved by, the management practices that farmers apply.

Wetlands Have Been Lost

Wetlands are a productive and valuable resource. In the past, however, extensive acreages have been drained and convented to other use. Wet areas may interfere with agricultural operations. Because the cost of draining these areas can, in some regions, be offset by the value of timber from mature hardwood stands and because of the profitability of crops grown on these sites, farmers have continued to drain wetlands in spite of federal and state restrictions and regulations. Areas where conversion is most likely to occur are in the South Atlantic-Gulf region and the Upper Midwest. Both the bottomland hardwood forests of the former and the prairie potholes of the latter regions are important wildlife habitat. "Swampbuster" provisions of the Food Security Act of 1985 are designed to discourage further conversion for production of agricultural commodities.

Resource Projections: What Might the Future Hold?

The Resources Conservation Act directs USDA to analyze resource capability and limitations for meeting the Nation's long-term interests. In response to this requirement, USDA estimated future demands and conditions. These estimates are "projections," not "predictions". Predictions are statements of what is expected to occur in the future; projections are calculations of what WOULD happen in the future IF certain specified conditions existed and current trends continued.

To make these projections of future conditions, USDA first analyzed the major forces that affect future demands on our soil and water. These forces are commodity demands, demands for land and water for nonagricultural uses, development of new production technology, productivity losses stemming from soil erosion, and the policies and institutions that affect resource use. For each of these, USDA made separate projections of the highest, lowest, and "intermediate" rates of change that could reasonably be expected.

The separate projections were then combined and their interaction analyzed using a linear programming model of the Nation's agricultural sector developed by the Center for Agricultural and Rural Development (CARD) at Iowa State University. The projected highest and lowest rates for the various forces were combined to permit simulation of the results of conditions that would cause varying degrees of stress on resources. The CARD analysis projected patterns of land and water use, based on the least-cost method of production and transport, to 1990, to 2000, and to 2030.

The analysis looked most closely at projections for "intermediate" assumptions, which are generally extensions of current trends. Under these assumptions, natural resources readily available to the agricultural sector are projected to decrease slightly and total commodity demands to increase considerably, but resources are projected to be adequate to meet demands. If demands were to increase faster than the intermediate rate and technology failed to provide the

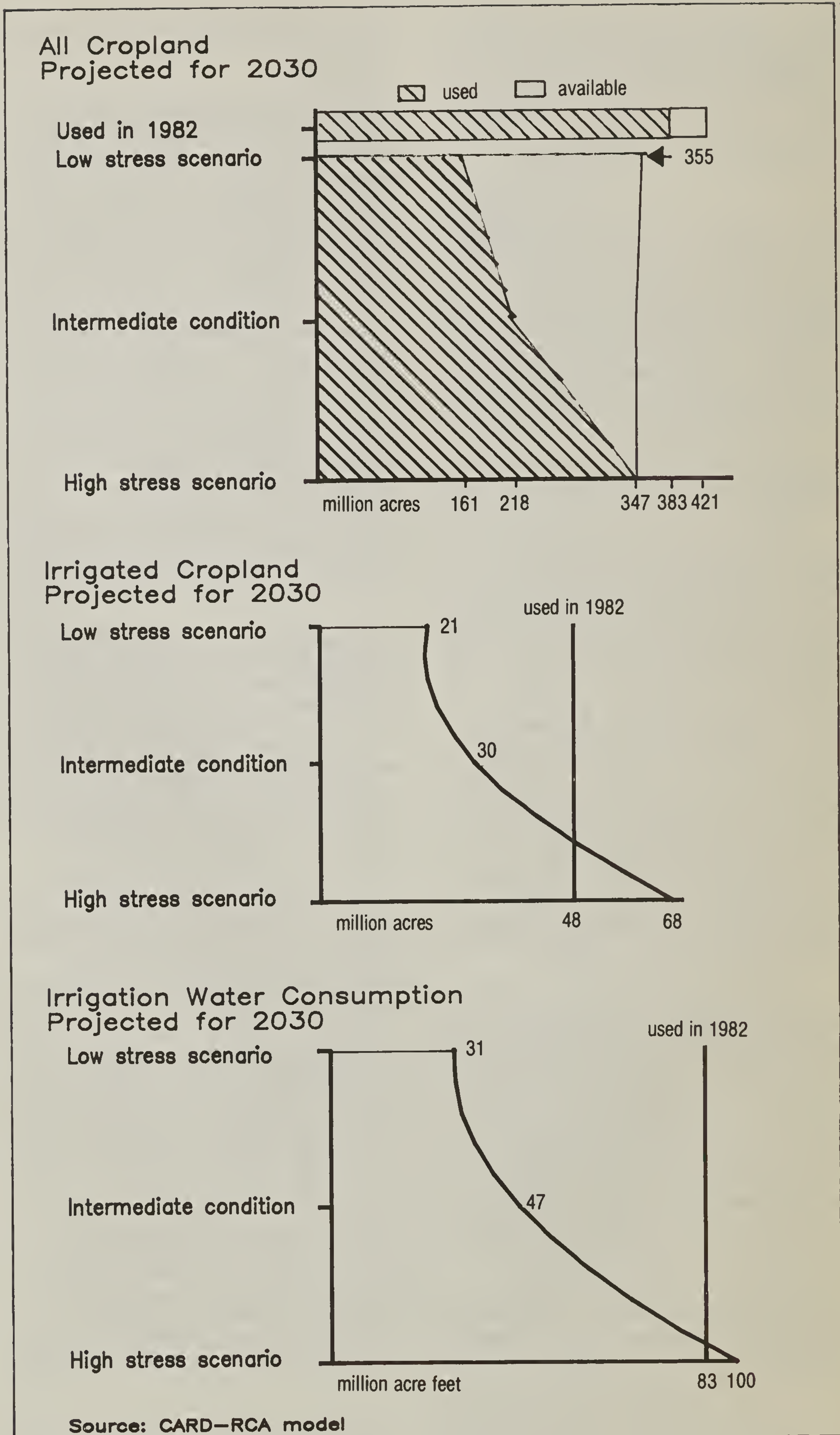


Figure 4.--Projected cropland and irrigation water in 2030, alternative scenarios.

increases in yields that experts anticipate, all cropland available in 2030 would have to be cropped, with the exception of 40 million acres of highly erodible land. Figure 4 summarizes projected cropland and irrigation water use in 2030 under the three scenarios.

Given the demand and yield assumptions of the analysis, the model calculates that the least-cost method of meeting the demand would entail not only significant reductions in the acreage required but major shifts in the location of production and major improvements in resource condition.

Projections suggest that, under all except the most extreme conditions, fewer acres might be irrigated and therefore less irrigation water would be used in the future. Assuming intermediate conditions and full implementation of the conservation provisions of the Food Security Act, slightly more than 30 million acres are projected to be irrigated in 2030, compared to 49 million in 1982. Assuming similar conditions in the absence of conservation efforts, even fewer irrigated acres are projected. Only at the highest levels of demand and slowest rates of increase in productivity studied are irrigated acres projected to increase. Under those assumptions, 68 million acres would be irrigated.

Assuming that there would be more than enough cropland to supply the Nation's needs, it should be possible to concentrate cropping on the best land, thereby reducing the chance for damage, both to the soil and to the offsite environment.

Erosion rates on land in major crops could decrease significantly. Assuming intermediate conditions, total erosion on cropland in commodity crops is projected to decline to less than 1 billion tons in 2030 compared to slightly less than 3 billion tons in 1982. Wind erosion is projected to decline because the acreage of cropland in areas subject to wind erosion is projected to decline. Sheet and rill erosion is projected to decline primarily because it is assumed that economic considerations will make some form of conservation tillage near-universal by 2030 and, to a lesser degree, because the conservation compliance provisions of the Food Security Act of 1985 will encourage conservation.

Assuming higher demands and smaller increases in productivity than the intermediate rates, and less effort to control erosion, projected wind erosion in 2030 would remain at the 1982 level and sheet and rill erosion would decline only slightly.

Projections include a livestock sector and a pastureland/ rangeland sector. The linear programming model calculates that the least-cost method of meeting demands would entail greater use of forage and reduction in the acreage of cropland required to feed livestock. Assuming intermediate conditions, including implementation of the conservation provisions of the Food Security Act of 1985, livestock are projected to consume 453 million tons of forage in 2030.

Projections do not consider some conditions because the processes are not understood well enough to model or because data are incomplete.

In making the projections, the model did not include erosion rates on rangeland, potential for range degradation, and opportunities stemming from improved range management or the conversion of cropland to pastureland.

Projections did not consider the effects salinity might have on cropland availability or productivity. The model projected that high percentages of cropland in the western half of the Nation, both irrigated and dryland, would be removed from production. Reduction in acreage cropped can be assumed to reduce the acreage where salinity is a problem. Continued availability of sufficient land for special crops grown in areas with current or potential salinity problems was assumed but was not analyzed in the models.

Projections do not consider the possible effects of increases or decreases in ozone or other atmospheric pollutants on yields and therefore on the land needed to meet future demands for food and fiber.

The linkages between the reduction in soil erosion and the resulting reductions in offsite damages are not fully understood and need to be studied further. Assuming that erosion were reduced to the levels projected under the "low stress" and "high stress" conditions analyzed for this appraisal, preliminary analysis indicates that annual reductions in offsite damages could range from $32.5 million to $145.5 million in the year 2030.

Projections of the effects of implementing the conservation title of the Food Security Act of 1985 suggest that erosion rates could be considerably lower with the act than they would be without it (fig. 5).

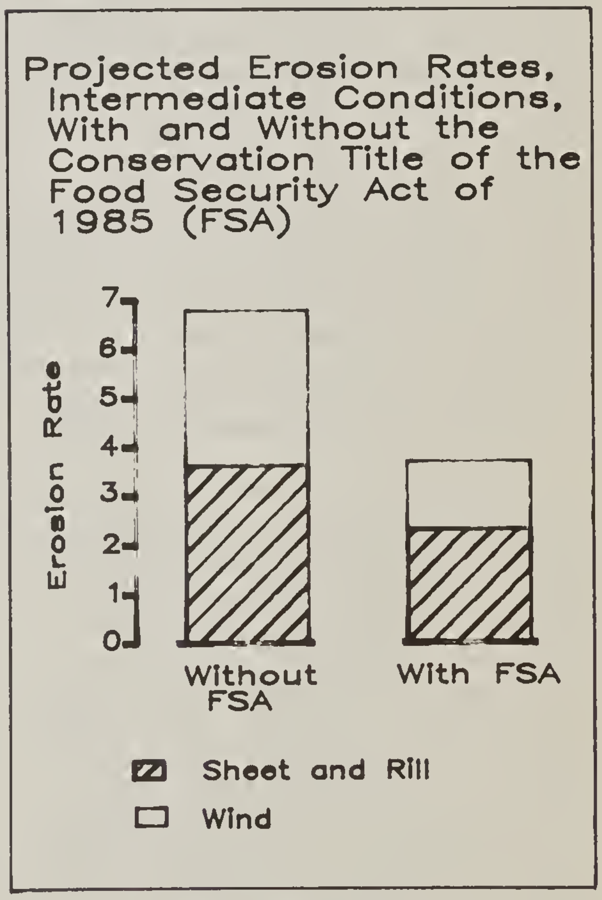


Figure 5.--Projected erosion rates (tons per acre) in 2030, intermediate conditions.

Two Appraisals, Different Projections

The projections presented in this second appraisal differ markedly from those shown in the first appraisal conducted in the late 1970's, even though similar techniques were used to make the resource projections for both. For each appraisal, projections were made for a series of different scenarios. Under the "intermediate" conditions assumed in this second appraisal, cropland acreage in 2030 is projected to be slightly less than 220 million acres whereas the first appraisal scenario comparable to this projected almost 390 million acres. Slightly more than 380 million acres were used for crops in 1982.

The differences in the two projections of acreages needed do not result primarily from differences in projected demand. In fact, for the major crops--corn, sorghum, soybeans, and wheat--projections of quantities needed are higher in the second appraisal than in the first, largely because projected export demands are higher (fig. 6). For other crops, particularly feed grains, projected quantities demanded are lower, largely because projected feed efficiency rates are very high and much greater use of pasture and range forage is projected and, to a lesser degree, because projections of per capita consumption of red meat are lower.

The differences in the projections of cropland needed result largely from differences in the projected rates of yield increase used in the two appraisals. The first appraisal projected crop yield increases of 1.1 percent per year from 1980 to 2000 and 0.8 percent per year thereafter. The second appraisal projected increases ranging from 1.0 percent per year (for alfalfa) to 2.6 percent per year (for soybeans) to 2000, and from 0.7 percent per year (alfalfa) to 1.2 percent per year (feedgrains) thereafter. These differences, when compounded over a 50-year period, resulted in marked differences in projected average crop yields (fig. 6 and appendix tables 56 and 57).

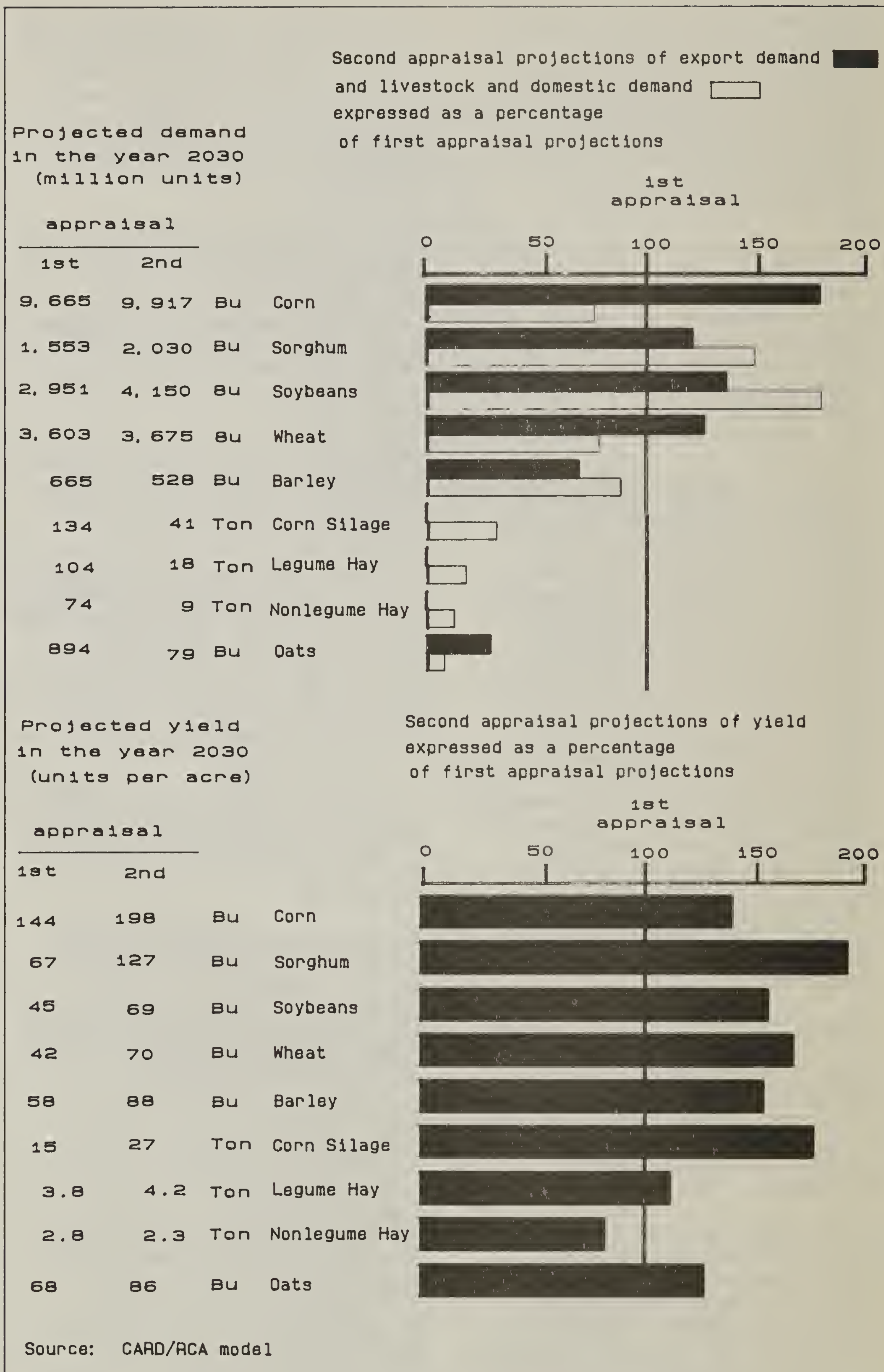


Figure 6.--Second RCA Appraisal projections of demand for and yields of major crops, expressed as a percentage of First Appraisal projections.

The assumptions about yield increases mirror the vastly changed view of the future that has developed during the past decade. In the early 1970's, many studies indicated that productivity was increasing more slowly than in preceding decades. Based on those studies, the appraisal assumed that "Without significant technological breakthroughs and increased investment in research and extension programs, the rate of growth in productivity will probably continue to decline." 1/ Research in the later seventies provided a basis for greater optimism. The 1982 symposium from which the productivity projections used in the second appraisal were taken reported that "The symposium authors tend to view favorably the opportunities for continued technological progress in crop and livestock production as well as in resource conservation." 2/ This view was also the consensus at a conference on agricultural productivity conducted by the National Academy of Sciences in 1986. 3/

It is, of course, possible that in making these latest projections analysts were too optimistic in assessing reports of breakthroughs in technology and gave too little weight to historic trends. What we have witnessed in the past 15 years is a cycle of "food pessimism" or "technological pessimism" followed by complacency, the sixth such cycle in 200 years. In 1798, Malthus wrote that scarcity and eventual famine were inevitable, given our predilection for procreation. The opening of new land for settlement and the industrial and agricultural revolutions averted the predicted shortages. The second episode of short-lived pessimism began in 1898; the third, after World War I. Three more followed World War II: in the immediate post-war period, in the late 1960's, and again in the early 1970's.

These cycles occur because need (demand) and resource use (supply) are constantly changing, interdependently but not in unison. Fueled by increases in world population and economic growth, supply and demand move in the same direction but not necessarily at the same time. These temporal lags result in the periodic short-term extreme resource stress such as that in the 1970's.

These periods of stress and pessimism are occurring with increasing frequency. It has been plausibly argued that another could occur before the end of this century. The projections in this report cannot be used as evidence that such an event will not occur because the analysis does not consider the full range of global political, economic, and climatic conditions that could produce severe shortages.

1/ U.S. Department of Agriculture. 1981. 1980 Appraisal: Soil, water, and related resources in the United States.

2/ Tweeten, Luther. 1984. Summary and synthesis. In: Future agricultural technology and resource conservation, edited by Burton C. English, James A. Maetzold, Brian R. Holding and Earl O. Heady. Iowa State University Press, Ames, Iowa.

3/ Ruttan, Vernon W. December 1986. Implication of technical change for international relations in agriculture. Conference on Technology and Agricultural Policy, National Academy of Sciences.

CHAPTER 2
Land Use Decisions Affect Productivity

Maintaining the productive capacity of agricultural land requires, as pioneer soil conservationist Hugh Hammond Bennett said, that people "use land according to its capability and treat it according to its needs." These two aspects of soil conservation interact--land used within its capability is less likely to be damaged and therefore needs less protection than land in uses for which it is not suited. Although most nonfederal agricultural land is used within its capability, considerable acreages are not. Much of this land is being damaged and consequently damages other land and water resources.

Land use is constantly changing, though the net change in the acreage in each use is slight in any single year. Changes in land use may have considerable effects in a local area or region while not appearing to require specific action at the National level. During the 1970's, however, rapid urban development in many areas of the country led to concern about the effects of continued development on the productive capacity and the environment of the Nation as a whole.

In the same period, much land was cleared and plowed for crops, reversing a decades-long trend. Not all the new cropland was suitable for cultivation, and many conservationists feared that the demand for more cropland, coupled with the loss of some of the best cropland, would result in greater damage both onsite and offsite. Economic conditions in the early 1980's temporarily slowed the rate of urban growth in many areas, lowered the demand for agricultural products, and encouraged agricultural imports, slowing the rate of land conversion and reducing concern about the effects of land use changes in the short-term. Because these conditions will also change over time, however, it is still necessary to appraise land use trends and prepare to deal with conditions that may reemerge over the long term.

Legislation was enacted in the 1980's to ensure that actions by the Federal government do not encourage poor choices in land use. The Farmland Protection Policy Act, included in the Agriculture and Food Act of 1981 and amended in the Food Security Act of 1985, requires Federal agencies to consider the effects their programs will have on prime farmland. The conservation provisions of the Food Security Act of 1985 are designed to ensure that USDA commodity programs do not subsidize unwise changes in land use. Program benefits will be denied to producers who drain wetlands or remove the plant cover from grass or forestland to plant agricultural commodities. This appraisal is based on inventories and analyses largely completed before the Food Security Act was enacted and regulations for its implementation approved. Therefore, estimates of the act's possible effects are not included in this report.

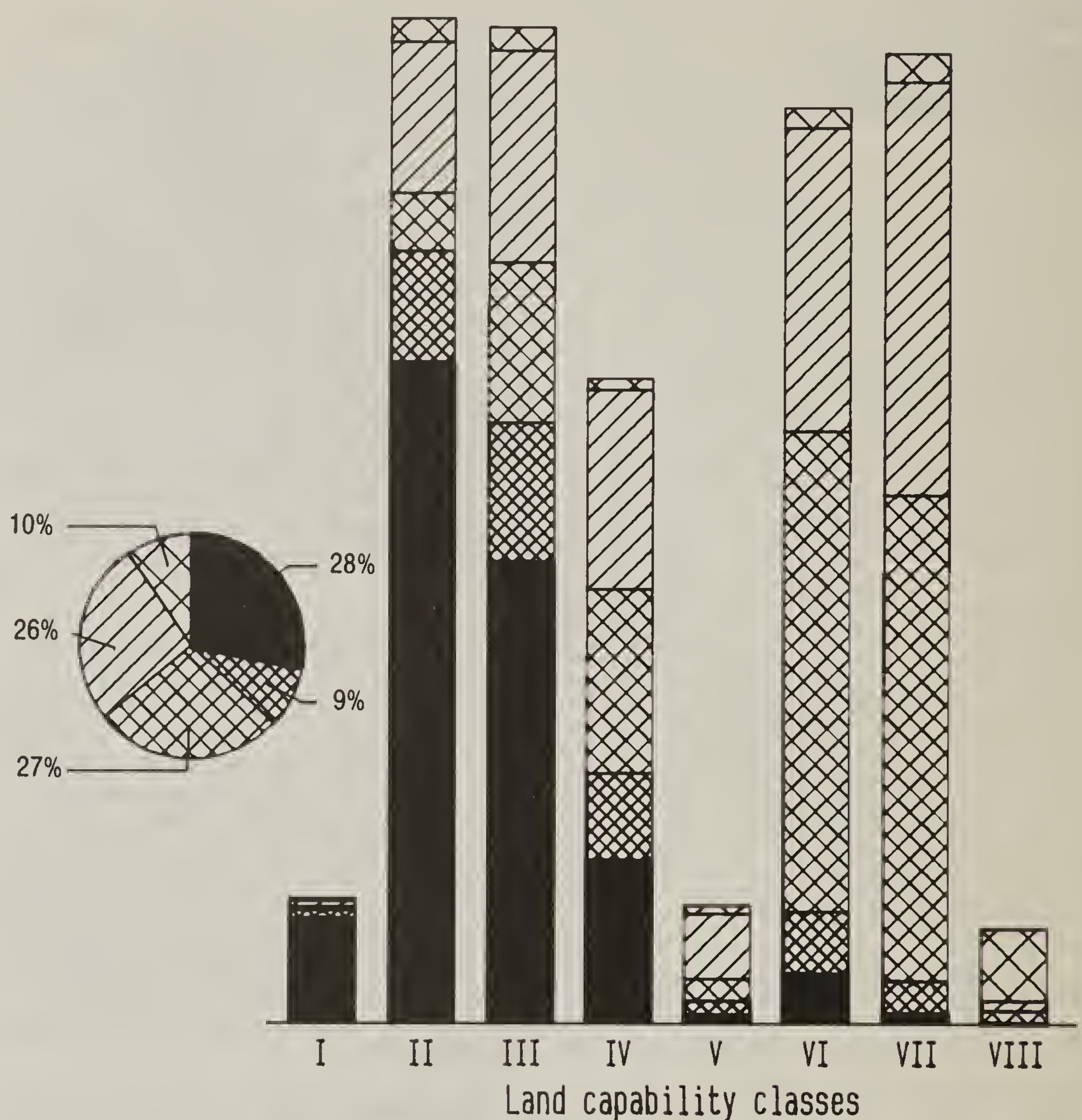
USE OF AGRICULTURAL LAND: Are we using land within its capability?

Farmers generally are using their land in a manner consistent with its capability as indicated by USDA's Land Capability Classification System (fig. 7). Almost all class I land, with soils that are level, deep, well drained, and easy to work, is being used as cropland. Because there is relatively little class I land, most cropland is in classes II and III. Soils in these classes are suitable for use as cropland but need protection with conservation measures when they are cultivated. Most land in classes V through VIII is used for pasture, range, forest, or other suitable uses such as wildlife habitat. About 19 million acres in these classes, however, are planted to crops even though land in these classes generally is not suitable for cultivation.

Evaluating land: Land Capability Classification

USDA's Land Capability Classification System is the most widely used method for judging the suitability of land for agricultural uses. The system has eight classes and four subclasses (fig. 8).

The eight land capability classes are the broadest categories of the system. Soils within a specific class have about the same degree of restrictions in use for crops and pasture or the same degree of risk of damage when used for crops. The soils in a class are similar only with respect to degree of limitation; each class includes different kinds of soil with different kinds of limitations. The higher the class numeral, the greater the limitations of the soils and the narrower the choices for their use.



(million acres)

		I	II	III	IV	V	VI	VII	VIII
Cropland	421	30	191	134	47	2	14	3	<1
Pasture	133	3	33	40	26	4	18	10	<1
Rangeland	406	<1	17	46	53	6	139	141	3
Forest land	394	2	44	61	58	19	88	119	3
Other land	60	<1	7	7	3	2	6	8	20
Total nonfederal	1,414	36	291	289	187	34	265	281	27

"Other land" includes all nonfederal rural land not included in the four agricultural categories.

Soils in classes I, II, and III are suited to cultivated crops. Soils in class IV can be used for crops, but only if crops are chosen with care or soil is managed with extra care. Soils in classes V, VI, and VII are, for the most part, not suited to cultivation but will produce pasture, range forage, trees, certain special crops or provide habitat for wildlife. (Applying pasture management practices, however, generally is not feasible on class VII land.) Land in class VIII has limitations that restrict its use mostly to recreation, wildlife habitat, or water supply.

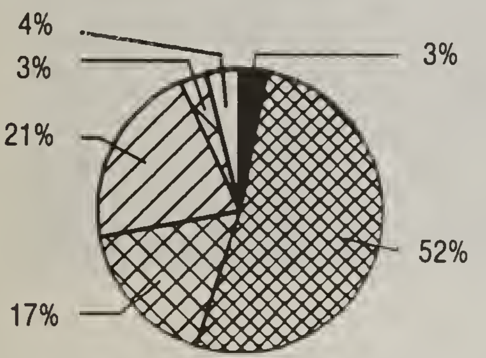
Source: USDA-SCS, 1982 National Resources Inventory

Figure 7.--Use of the Nation's nonfederal rural land, by capability classification. For additional data, see appendix tables 1 and 2.

All classes except I are divided into subclasses. Soils in a given subclass have the same kind of dominant limitation for agricultural use. There are no subclasses in class I because the soils have no significant limitations to use. The four subclasses are erosion hazard, wetness, unfavorable characteristics of the root zone, and climate.

The capability classification system was designed to assist farmers in planning the use and conservation of their land. The class designation is a rating of the risk of soil damage or the limitations to use of the soil. The class desigNation is not a measure of the severity of the limitation indicated by the subclass symbol. For example, land in class IIIe is not in all cases more susceptible to erosion than land in class IIe. Some other limitation may make the class IIIe land of lower capability than the class IIe land.

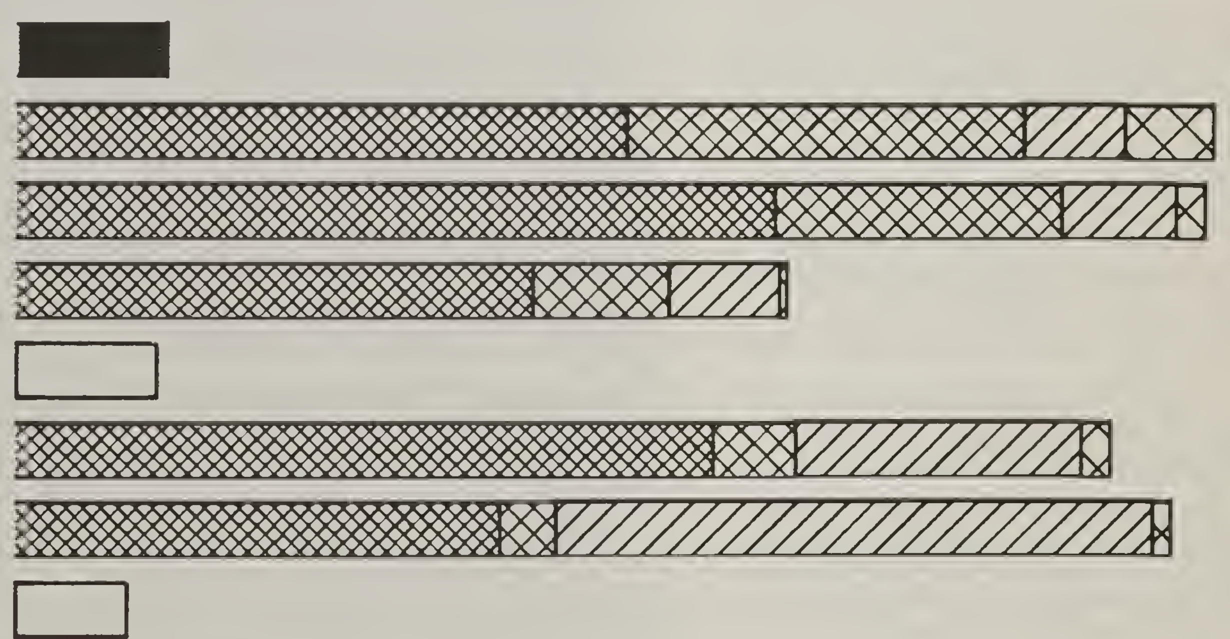
Land is classified according to its major limitation. Some soils have more than one limitation. These soils are assigned to a subclass based on the most restrictive limitation. For example, where wetness is a severe problem and the risk of erosion is moderate, soils are classified as "w" subclass. Where two kinds of limitation are essentially equal, the subclasses are given the following priority: e, w, s, c. For example, a few soils in humid areas have both a hazard of erosion and a limitation caused by excess water; these soils are assigned to subclass e.



Subclasses in the USDA Land Capability Classification System

e--soils where susceptibility to erosion is the dominant hazard.
w--soils where excess water is the dominant hazard or limitation to use. Excess water may be caused by poor soil drainage, high water table, flooding (including stream overflow, tidal inundation, ponding, and runoff from higher areas), or seepage.
s--soils with limitations in the root zone. The root zone may be shallow or stony, have low moisture-holding capacity or low, difficult-to-correct fertility, or contain salts or exchangeable sodium in amounts toxic to plants.
c--soils where the climate (temperature or lack of moisture) is the only major limitation.
Soils in class I have no significant limitations to use.
Data on subclasses were not collected for soils in class V and class VIII.

Subclass e	w	s	c	Total	Class
(million acres)					
				36	I
148	96	24	23	291	II
183	69	28	8	289	III
124	33	27	2	187	IV
				34	V
168	20	69	7	265	VI
117	15	144	5	281	VII
				27	VIII



Source: USDA-SCS, 1982 National Resources Inventory

Figure 8.--Nonfederal rural land, by capability class and subclass. For more complete data, see appendix table 1.

Changes in Land Use: Are They for the Better?

The use of privately held land is constantly changing. Farmers plow grassland and clear forest land so that they can plant crops. They allow land that was in crops to return to grass or trees. Developers build houses and shopping centers across what was farmland (fig. 9). Units of government convert cropland to water storage areas to provide flood protection for downstream areas, hydroelectric power, or water to irrigate other land.

Changes in land use are an inevitable part of a dynamic society. Not all changes in land use are desirable, however. Prime farmland, once converted to urban use, will never again be available for agricultural production. Where fragile or highly erodible land is planted to cultivated crops, erosion increases and so does the resulting damage to the soil onsite and the land and water downstream or downwind. Where wetlands are drained, wildlife habitat is reduced and the beneficial effects wetlands have on water quality and water supply are lost.

URBAN SPRAWL: How rapidly is it occurring?

It is difficult to determine precisely the annual rate of conversion of land from agricultural to urban uses. Data on the acreage of land in various uses are collected by USDA and by the Bureau of the Census. Differences in definitions and procedures have caused widely differing estimates of the rate of conversion (fig. 10).

Several social and economic changes over the past 25 years have influenced the rate at which land is converted to urban uses. Population growth and changes in age distribution, the economy, and transportation have contributed to changes in land conversion rates.

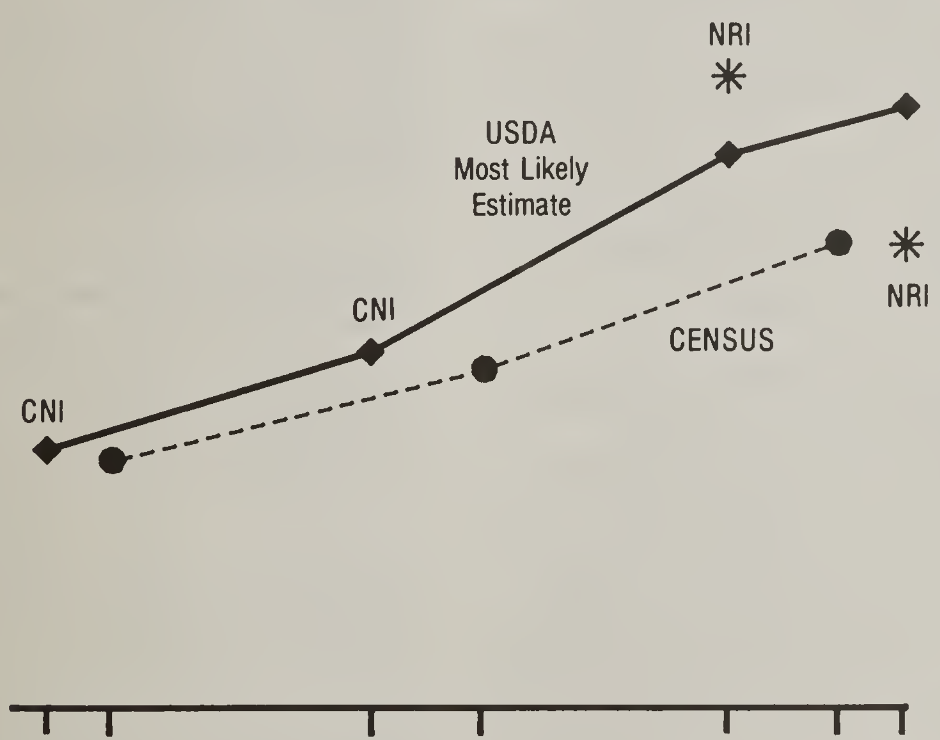
For most of the 1960's, between 0.9 million acres (Bureau of the Census) and 1.1 million acres (USDA inventories) per year were converted to nonagricultural uses. Factors influencing this conversion were the increase in new housing starts, expansion of urban

Figure 9.--The same area in Santa Clara County, California, in aerial photographs taken 28 years apart. Farmland, mainly orchards, in top photo is nearly covered with housing in bottom photo.

areas, improvements in rural transportation, and the beginning of the interstate highway system.

Between 1967 and 1977, the rate of conversion of agricultural land was 1.8 to 2.1 million acres per year, highest in the history of the United States. A number of factors contributed to the high rate of conversion. The interstate highway system was expanding rapidly (fig. 11). This permitted people to live farther from their place of work, encouraging expanded suburbs. The maturing baby-boom generation pushed the average annual rate of housing starts to its highest rate (fig. 12). The federal government increased its assistance to state and local governments for construction of sewage, water, and transportation systems--on land that had been farmland.

From 1977 to 1982, the average annual rate of conversion to urban uses returned to between 0.9 and 1.1 million acres per year. This short-term decrease can be attributed to high interest rates, which sharply reduced new construction; local, state, and federal programs to control urban sprawl; completion of the interstate system; a sluggish economy; and higher transportation costs. Since 1982, interest rates have decreased and there is some evidence that the average annual rate of conversion to urban uses has begun to increase again.



	1958	1960	1968	1970	1977	1980	1982
Census		25		34		47	
CNI/NRI	26		36		64		47
Most Likely	26		36		56		61

Estimates are in millions of acres.

The Bureau of the Census and USDA estimates differ because they are based on different definitions of "urban land." The Census counts as urban land central cities, adjacent urbanized areas and unincorporated or incorporated areas of 2,500 or more people. USDA also counts built-up areas of fewer than 2,500 people.

Because sampling procedures differed, USDA inventories in 1967, 1977, and 1982 cannot be compared to establish a trend.

The "most likely" acreage of urban land was established by using the 1958 CNI as a base and assuming the annual rates of increase reported in the Census, with slight adjustments to account for conversion in areas of fewer than 2,500 people.

Figure 10.--Conversion of land to urban uses, 1958-82. USDA inventories are discussed on page 20.

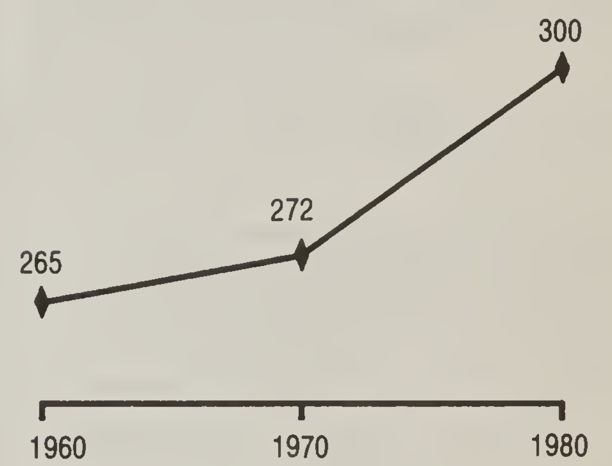


Figure 11.--Primary highway miles, 1960, 1970, 1980 (in thousands).

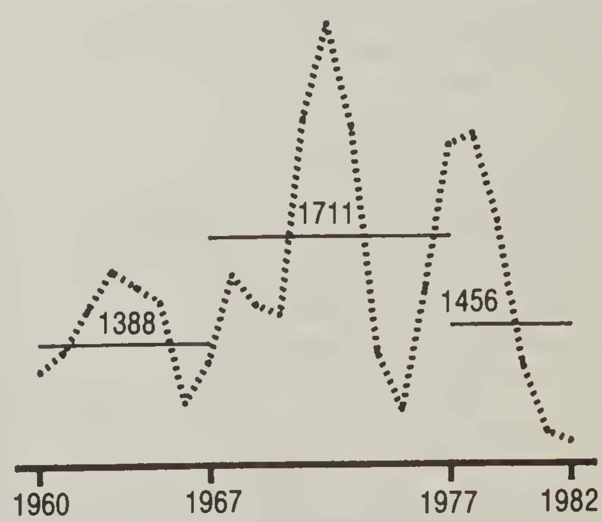


Figure 12.--Reported annual new housing starts, 1958-82, and average for 1958-67, 1967-77, and 1977-82 (in thousands).

Conversion of land from agricultural to nonagricultural uses is most likely to occur in the Nation's 676 metropolitan counties and the 787 adjacent counties. The growth of rural population has slowed from the pace of the 1970's, when population increased at a higher rate in rural areas than in metropolitan areas. From 1980 to 1982, metropolitan areas continued to grow at about 1 percent per year, while growth in rural areas decreased to an average of 0.8 percent.

Metropolitan counties contain about 20 percent of the Nation's cropland and 20 percent of the land with high and medium potential for conversion to cropland.

USDA Inventories of Urban Land

Conservation Needs Inventory/ National Resources Inventory (CNI/NRI).--SCS has conducted four major inventories of soil and water resources in the last quarter century. The definition of "urban and built-up land" was similar for all four. However, neither the purposes of the surveys nor the procedures for estimating the extent of urban land were identical. As a result, the 1977 and 1982 NRI estimates of urban and built-up land are not comparable.

The 1977 NRI and the 1975 Potential Croplands Study were designed to answer questions about the adequacy of resources, questions that had been asked because export demands were rising rapidly. The focus was on the amount and quality of land available for future use. Because land zoned for development or included in developing areas was considered unlikely to remain in agricultural use over the long-term, such land was not counted as part of the cropland base.

Some areas counted as urban and built up in 1977 included land on which development had not yet occurred. If future urban development were largely confined to filling in such areas, considerable development could occur without great effect on land still in agricultural uses. In this situation, more precise data were needed to track the rate and location of land conversion and its effect on local areas and the Nation. The 1982 NRI was designed to provide data that could be used as a base line for measuring future changes. In the 1982 NRI, therefore, land was not considered "urban and built-up" unless it was completely developed. This criterion resulted in an estimate of urban and built-up land lower than the 1977 estimate and lower than estimates produced by other studies based on other data. It is even lower than the 1980 Census, which does not count all land the NRI includes as agricultural land. Analysis suggests that had the 1977 and 1982 NRI involved identical methodology and purposes, the 1977 estimate of urban and built-up land and rural transportation land would have been about 82 million acres rather than 90 million, and the 1982 estimate would have been about 88 million acres rather than 74 million. These adjusted NRI figures are the "Most likely" values shown in figure 9.

National Agricultural Lands Study (NALS).--The NALS examined and attempted to account for shifts in uses of land from agriculture to nonagricultural uses. It also accounted for shifts among agricultural uses and from agricultural uses to water storage and distribution, rural transportation, rural housing, and other nonagricultural uses. The NALS counted land idled near urban centers but not yet built on as having been converted to nonagricultural uses. The NALS agreed with the original 1977 NRI estimate that approximately 2.9 million acres of all lands capable of agricultural production had been converted to nonagricultural uses annually between 1967 and 1977. Adjusted to correct for overcounting in the 1977 NRI, the NALS estimate is 2.1 million acres per year.

The NALS was conducted by USDA and the President's Council on Environmental Quality, with support from 10 other federal agencies. It used data from the Census of Agriculture and the General Census, the SCS 1977 National Resources Inventory, the SCS Potential Cropland Study of 1975, the Forest Service's Renewable Resources Assessment of 1975, and other sources.

AGRICULTURAL LAND LOST: Most likely to be prime farmland

The land most likely to be converted to nonagricultural uses is prime farmland, land on which crops can be produced for the least cost and with the least damage to the resource base. That is because agriculture was the basis for most permanent inland settlements in the United States. Settlements were located in the center of the most fertile areas and near rivers that offered a source of water and transportation. As the agricultural enterprises prospered, the settlements grew outward. Because the industrial revolution demanded large concentrations of people, industries were founded in the larger settlements. Most U.S. cities and larger rural towns, therefore, are surrounded by productive agricultural land and any expansion must occur on such land.

More than 60 percent of the agricultural land converted to nonagricultural uses comes from cropland. 1/ Ninety percent of the cropland likely to be converted to nonagricultural uses in the next 50 years is estimated to be prime farmland. 2/

Conversion of land to nonagricultural uses is more likely to be a concern in areas where the acreage of prime farmland is limited (fig. 13). Conversion may also be a concern where the land that is being converted has been designated as unique and important to the state.

In 1982, about 342 million acres of the Nation's 1.5 billion acres of nonfederal land were classified as prime farmland. About two-thirds of prime farmland is used as cropland. In some states, large acreages of prime farmland are in other agricultural uses (table 2).

1/ U.S. Department of Agriculture, Economic Research Service. 1976. Dynamics of land use in fast growth areas. No. 325.

2/ U.S. Department of Agriculture, Economic Research Service. 1984. U.S. cropland urbanization, and land ownership patterns.

Table 1.--States with largest percentage of cropland defined as prime farmland, top ten states

	CROPLAND that is prime farmland (1,000 acres)	Percent of total cropland
Texas	19,230	57.7
Illinois	19,089	77.2
Kansas	19,007	65.3
Iowa	16,684	63.1
Minnesota	16,051	69.7
North Dakota	12,683	46.9
Indiana	11,191	81.2
Nebraska	19,600	96.7
Missouri	9,863	65.8
Ohio	9,764	78.4

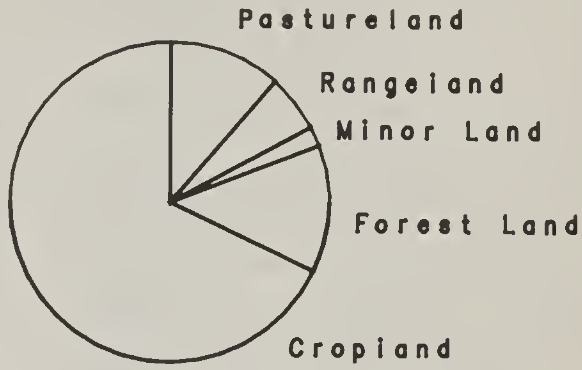
Table 2.--Prime farmland not used as cropland; top ten states

	(1,000 acres)
PASTURELAND	
Texas	5,526
Missouri	3,761
Oklahoma	3,337
Arkansas	2,226
Mississippi	1,781
Louisiana	1,592
Tennessee	1,570
Kentucky	1,506
Alabama	1,497
Kansas	1,345
RANGELAND	
Texas	10,198
Kansas	4,665
Oklahoma	3,015
Nebraska	692
North Dakota	602
South Dakota	414
Missouri	74
Minnesota	73
Idaho	56
California	45
FOREST LAND	
Louisiana	5,488
Mississippi	3,088
Minnesota	2,993
Alabama	2,750
Arkansas	2,675
Georgia	2,673
Virginia	2,649
North Carolina	2,179
Wisconsin	2,118
Pennsylvania	1,413

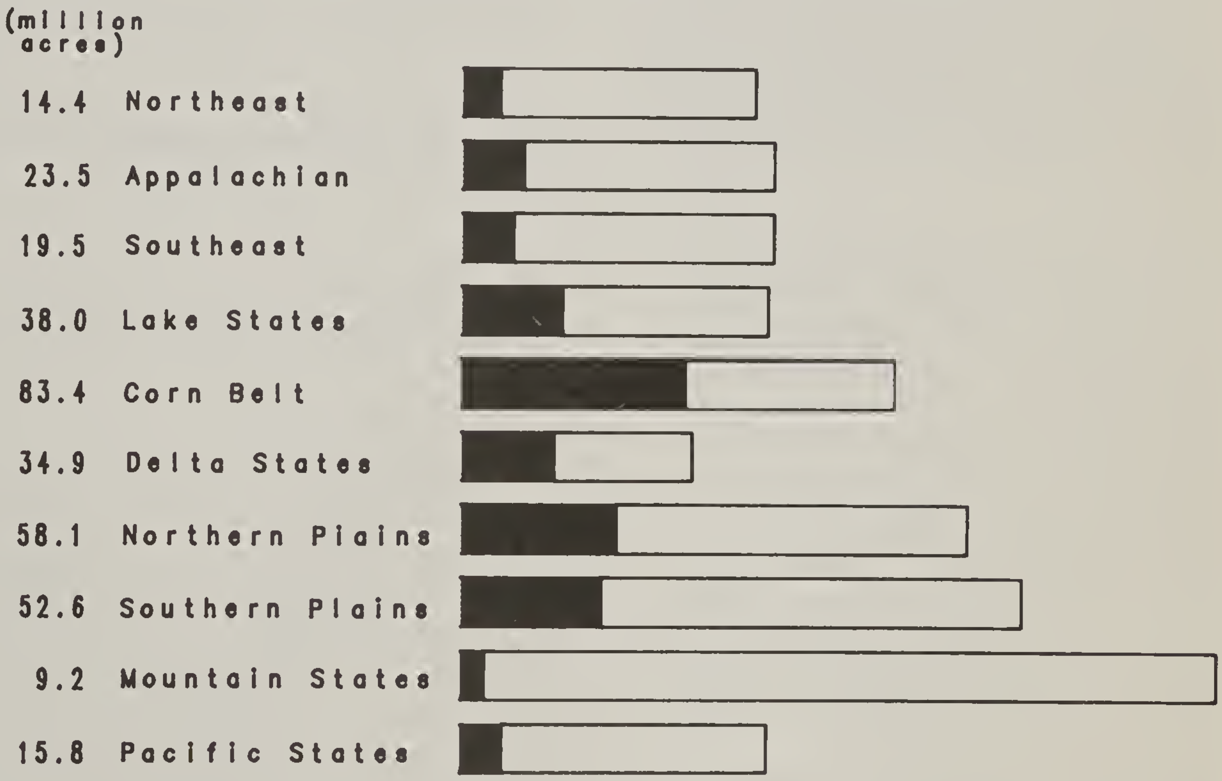
Source: USDA-SCS. 1982 National Resources Inventory.

Use of Prime Farmland

	Million Acres	Percent
Cropland	233	68
Pastureland	39	11
Rangeland	20	6
Minor Land	7	2
Forest Land	44	13



Prime Farmland Compared to all Nonfederal Land, by Region



Prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation and favorable temperature and growing season. The soils have acceptable acidity or alkalinity, acceptable salt and sodium content, and few rocks. They are permeable to water and air. They are not excessively eroded. They are flooded less often than once in 2 years during the growing season and are not saturated with water for a long period; that is, the water table is maintained at a sufficient depth during the growing season to allow cultivated crops common to the area to be grown. The slope ranges mainly from 0 to 5 percent. To be classified as prime, land must meet the criteria and must be available for use in agriculture. Land committed to nonagricultural uses is not classified as prime farmland.

Source: USDA-SCS, 1982 National Resources Inventory

Figure 13.--Prime farmland. For additional data, see appendix table 5.

NEW CROPLAND:
Are we sowing new problems?

For most of the period since 1930, the acreage of cropland has been decreasing. As increasing export demands in the 1970's brought higher prices for agricultural commodities, the acreage under cultivation began to expand again (fig. 14). The increase in demands for crops and resulting increase in land cropped introduced concerns that had not existed when low prices induced farmers to reduce the acres they planted. Was the slow progress toward removing marginal, erodible land from cultivation to be wiped out? Were damages to land and water likely to increase rapidly as a result of high erosion rates in new cropland? In some states, there is evidence that fragile or highly erodible land has been converted to cropland. And NRI data on potential cropland, which reflect land being converted, indicate that in most areas expansion of cropland would mean land with greater limitations would be brought into cultivation.

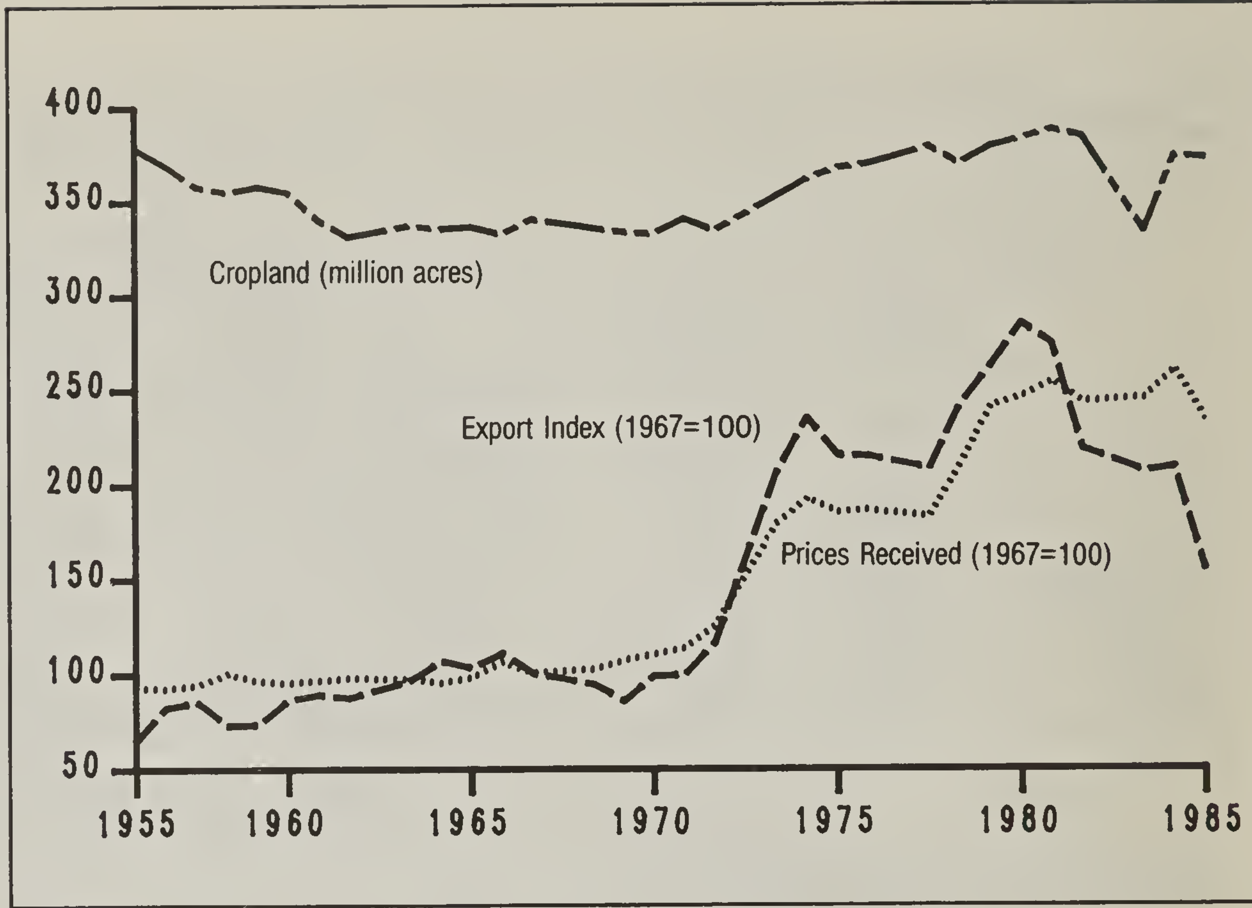


Figure 14.--Cropland, exports, and farm prices, 1955-85.

Potential Cropland.--In the 1975 Potential Cropland Study and the 1977 and 1982 National Resource Inventories, USDA estimated the acreage of nonfederal land that had potential for conversion to cropland in the short-term. Of the nearly 1 billion acres not used as cropland, half has no potential for conversion to cropland and another third has only low potential. About 118 million acres have medium potential for conversion, according to the criteria in the 1982 NRI, and about 35 million acres have high potential for conversion.

Potential cropland in the NRI means land that might be converted to cropland in the next 10 to 15 years, based primarily on commodity prices, development costs, and production costs in the year preceding collection of data. Land was rated as having high potential for conversion to cropland if there was evidence that similar land had been converted during the preceding 3 years.

Figure 15.--Land with high potential for conversion to cropland. For more complete data, see appendix table 6. The dot pattern is computer generated and does not show exact sites within a state.

Potential cropland is not evenly distributed across the Nation (fig. 15 and 16). Half of the

Table 3.--Quality of present and potential cropland, as indicated by percentage distribution among land capability classes

Class	Cropland in 1982		Land with potential for conversion to cropland: High		Land with potential for conversion to cropland: Medium	
	(million acres)	(percent)	(million acres)	(percent)	(million acres)	(percent)
I	30.2	7	1.7	5	1.5	1
II	191.3	45	17.0	48	31.6	27
III	133.7	31	11.6	33	43.9	37
IV	47.0	11	3.2	9	25.8	22
V	2.4	1	0.3	1	2.4	2
VI	14.1	3	1.2	3	11.1	9
VII	2.8	1	0.3	1	1.4	1
VIII		---		---		---
Total 1/	421.4		35.3		117.6	

1/ Totals are not exact due to rounding.
For more complete data, see appendix table 7.

Source: 1982 NRI

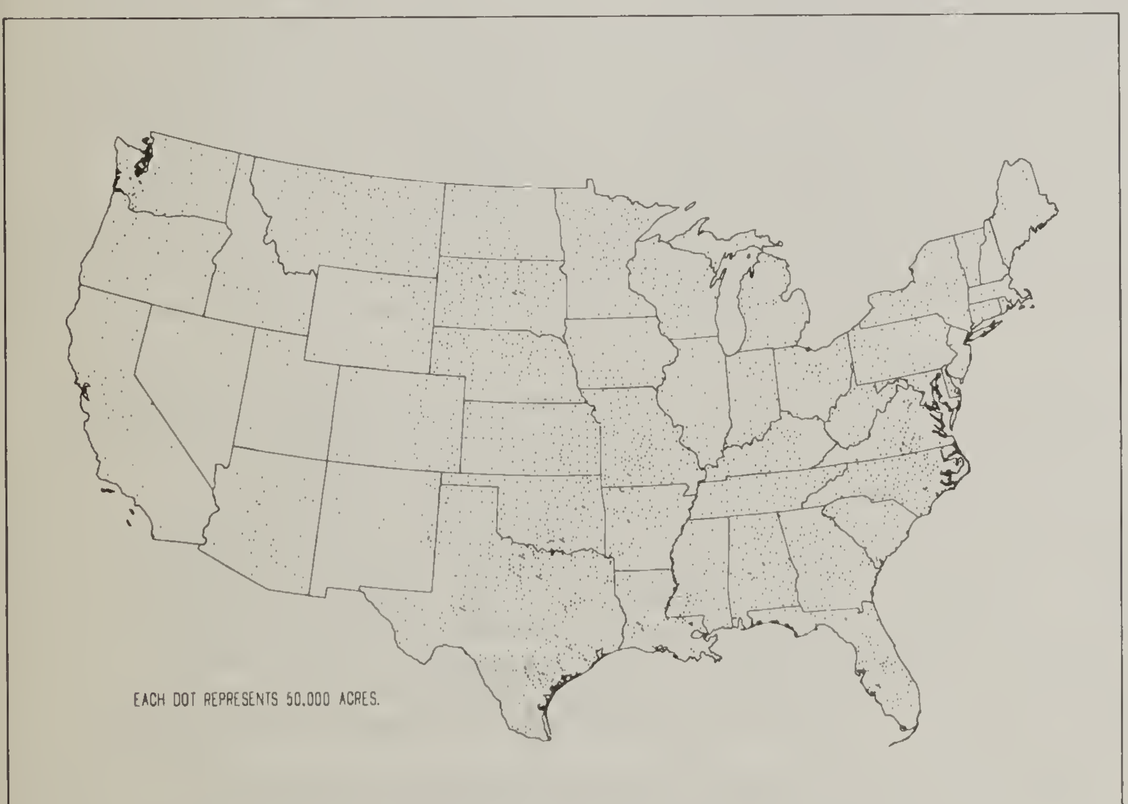


Figure 16.--Land with medium potential for conversion to cropland (1982 NRI). For more complete data, see appendix table 6. The dot pattern is computer generated and does not show exact sites within a state.

land with high and medium potential for conversion to cropland is in only 10 states: Texas, Missouri, Oklahoma, North Carolina, South Dakota, Montana, Kansas, Nebraska, Alabama, and Florida.

Most of this potential cropland is not idle; it is in other uses and generally is highly productive in those uses. For example, if all of the 12 percent of nonfederal rangeland with high and medium potential for conversion (49 million acres) were converted to cropland, range forage production likely would be reduced 19 to 24 percent.

On a nation-wide basis, land with high potential for conversion differs only slightly from existing cropland as indicated by the distribution among capability classes (table 3). Land with medium potential for conversion, however, includes a far greater percentage of land in more limited capability classes.

STATES ARE IMPLEMENTING PROGRAMS TO PROTECT PRIME FARMLAND

Connecticut. A state purchase of development rights program has been established to help slow the rate of agricultural lands to nonagricultural uses. The program is effective on a limited scale, but it is not able to preserve most of the prime farmland. Communities are encouraged to adopt agricultural preservation programs that include local development rights purchase, transfer of development rights, agricultural districts, and other innovative methods. In addition, farmers are searching for higher-value, more competitive crops such as nurseries and vineyards.

Massachusetts. In 1977 Massachusetts authorized the Agriculture Preservation Restriction Program, a voluntary plan whereby farmers can be paid the difference between the land's fair market value and its agricultural value. A deed restriction is recorded, prohibiting activities that are detrimental to agricultural land use.

New Hampshire. Because of the limited agricultural base, about 85 percent of the food consumed is produced outside the state, and prices are 10 to 15 percent higher than in other parts of the country. Through a special effort financed partly by RCA funds, two counties have developed an index that rates soil potential for agricultural uses and for development. These ratings can be used to identify the most important local agricultural lands, choose methods to retain these lands, and determine treatment needs and costs for developing lands less important for farming.

Rhode Island. The people of Rhode Island recently approved a $2 million bond referendum for the purchase of development rights on farmland, the second such measure in 3 years.

Vermont. SCS is cooperating with the University of Vermont to develop a statewide data base to help plan orderly growth and development.

Alaska. Since 1959 nearly 120 million acres of federal land have been transferred to state and private ownership. Native Alaskans--Eskimos, Indians, Aleuts--have acquired more than 34 million acres under the Alaska Native Claims Settlement Act, and another 10 million acres will be conveyed to them over the next few years. Pressures are mounting to develop lands now used as wildlife habitat, woodland, rangeland, and cropland, for oil and gas exploration and development, transportation corridors, and urban development. Changes carried out without proper precautions could lead to extensive problems with erosion, water quality, and flooding. In preparation, Alaska's major concern is to provide adequate resource inventories, baseline data, and planning assistance.

Hawaii. The state legislature established the Hawaii Land Evaluation and Site Assessment (LESA) Commission to formulate a system to identify important agricultural lands. The 17-member commission, which includes a soil and water conservation district official, has prepared a recommendation based on the LESA system introduced earlier by SCS. After determining the acreage needed to reach Hawaii's agricultural goals for 1990 and 1995, each island's agricultural land requirement was estimated. The LESA system recommended by the commission has to be approved by the state legislature and the Governor. After that step, the law will designate an administrative agency to map the boundaries for important agricultural lands. The state and counties will use these findings to assist with decisions on land conversions.

Kentucky. In 1982 the state enacted the Agricultural District and Conservation Act to protect agricultural land. The act authorizes establishment of agricultural districts, places responsibility for the program with the 121 conservation districts, and gives administrative responsibility to the Kentucky Soil and Water Conservation Commission.

CHAPTER 3
Erosion Is Reducing the Productivity of Some Soils

The natural process of erosion has been important in shaping the landscape in which we live. This natural, or geologic, erosion is seldom a problem from the human standpoint. However, erosion can be accelerated by human activities that alter the plant cover protecting the soil. Accelerated erosion can make both the land where it occurs and land and water downstream or downwind less productive or less suitable for human use.

In 1982, sheet and rill erosion moved more than 1.8 billion tons of soil on cropland, and wind erosion moved 1.2 billion tons. More than 173 million acres of cropland are eroding at rates greater than the soil loss tolerance. About 23 percent of cropland is eroding at two or more times the soil loss tolerance. Classic gully erosion and the concentrated-flow erosion called "ephemeral gully" erosion are also damaging cropland.

USDA has developed a system for indexing the sensitivity of soil to erosion damage. This "EI" system indicates the need for erosion control more precisely than other systems of classifying soil erosion hazards. Most of the acres eroding at rates greater than tolerance are moderately sensitive to very highly sensitive to erosion damage. Moderately sensitive land can be protected against erosion. Land with a very high EI value generally can be protected only by maintaining permanent vegetative cover.

Soil erosion can reduce onsite capability of the soil to produce crops and can increase the costs of farming. Erosion can cause both short-term and permanent damage. Various methods have been used in efforts to quantify the degree of soil damage or the cost of erosion. Results of such efforts must be regarded as preliminary and incomplete at present.

A new computer model (EPIC) estimates that, under 1982 management conditions, 77 million acres of cropland are eroding at rates that would result in loss of 5 percent or more of their productivity within 100 years. This loss is the equivalent of losing production worth more than $9 billion at 1980 prices.

This chapter reports information on the changes erosion causes on the site where erosion occurs. Onsite erosion can cause short-term damage (damage to crops) or long-term damage (damage to soil). This chapter reports data on the long-term damage. Because erosion on cropland accounts for half of all wind erosion and more than half of all sheet and rill erosion on rural nonfederal land (fig. 17), most of the data and analyses in this chapter concern erosion on cropland.

More precise methods are needed to quantify the effects of erosion on productivity and assign dollar values to the loss of productivity for the Nation. This chapter describes where sheet and rill erosion and wind erosion are causing damage to agricultural soils and reports the best estimates available on the extent of the damage. Gully erosion and "ephemeral gully" erosion on cropland are not included in these estimates. Chapter 13 of this report describes the methods used to study erosion.

When erosion damages the plants growing on agricultural land, it costs the farmer or rancher. In addition, erosion can affect the cost and ease of managing land. Data on the costs imposed by these damages have not been collected, however, and estimates of erosion damages reported in this chapter do not include them.

When soil is carried away from the site, it can reduce air quality, water quality, or land productivity and cause hazards to human health and to wildlife. It also can increase flood damages and increase operating and maintenance costs for many kinds of industrial activities and transportation. Offsite damages likely cost more than onsite soil damages and directly affect far more people. Offsite damages caused by erosion and runoff from agricultural land are discussed in chapter 10 of this report.

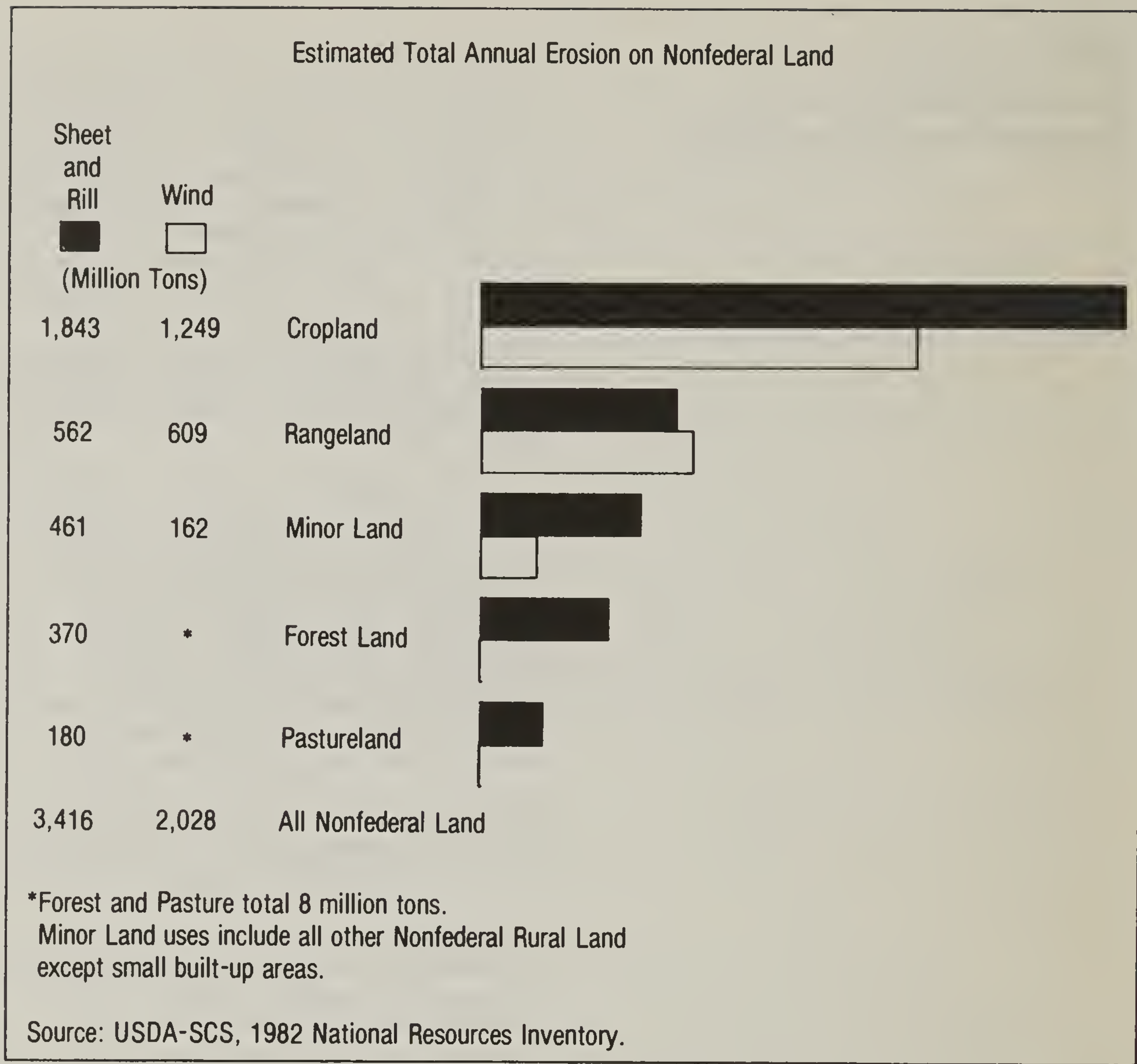


Figure 17.--Estimated average annual sheet and rill and wind erosion on nonfederal rural land, by land use, million tons (1982 NRI). Appendix tables 8 and 9 give additional data, by state. Erosion is measured in tons of soil moved per acre per year. Ephemeral gully and gully erosion were not estimated in the 1982 NRI. The NRI estimates represent not the precise erosion in 1982 but the anticipated **average** rate assuming that land use and management observed at the time of the inventory were unchanged for 30 years.

Erosion occurs in several distinct forms. In sheet and rill erosion, raindrops loosen soil particles, which are then carried to new locations by rainwater flowing over the field. Fast-moving water cuts small channels, or rills, that join to become larger channels. On cropland, these channels are called "ephemeral" gullies because the channels disappear when the field is tilled. But each year they reappear in the same area after the first heavy rainfall. Eventually they deepen and widen into gullies. Wind erosion occurs when the force of wind blowing over unprotected soil overcomes gravity.

All forms of accelerated erosion can impair the soil's ability to produce healthy and abundant crops. Erosion can reduce productivity not only where it removes topsoil from a field but also where the eroded soil is deposited. In addition, it can reduce productivity when it moves soil around within a field even if little soil actually leaves the field.

Erosion removes topsoil, reducing soil productivity by depleting the soil of nutrients and reducing its ability to absorb and store water and to serve as a seedbed for plants.

Erosion also damages land by moving soil around, removing it from some parts more than others. This makes the fertility of land more variable, so that it requires more fertilizer in some places than in others. Since machines are used to apply fertilizers, the farmer is faced with the choice of fertilizing the eroded parts too little and cutting potential production or fertilizing the uneroded parts too much and increasing fertilizer costs. The effectiveness of herbicides may also be affected by increased soil variability.

Deposition of eroded material over fertile soils can also reduce productivity. Although deposition may, in a few areas, initially increase fertility and produce increased plant growth, additional deposits usually have no further benefits.

Erosion's Effects Vary

Erosion is a natural process that occurs whenever the protective plant cover is disturbed. Agricultural production necessarily involves some disturbance of the vegetation; hence some erosion will occur on agricultural lands. The goal of soil conservation efforts is to ensure that erosion does not exceed a rate that will permit a high level of productivity to be sustained economically and indefinitely. 1/

The areas where average erosion rates are highest or where the most tons of soil are eroded are not necessarily the areas where erosion is causing the most severe damage to soil properties and to yields. For example, on some soils of the Midwest formed from loess, the subsoil contains less organic matter than the surface layer but is very similar to the surface soil in all other physical and chemical characteristics. Erosion of these soils removes some plant nutrients and organic matter but does not cause much loss in productivity until a sufficient volume of soil has been lost to cause significant reduction in the remaining soil's water-holding capacity. In a few places, this occurs only after many feet of soil have been eroded.

In most places, however, bedrock or some soil layer that is impenetrable to plant roots is closer to the surface, and a much smaller soil loss reduces soil productivity. Many soils in the southeastern United States, for example, have a very thin topsoil and a subsoil that is clayey and very low in organic matter and plant nutrients. This subsoil fixes phosphorus, making it unavailable to plants, and in many cases also contains toxic elements, such as aluminum. As the soil erodes, plowing mixes more and more of the subsoil into the surface layer. The result is a surface soil that has unfavorable chemical characteristics and reduced infiltration capacity.

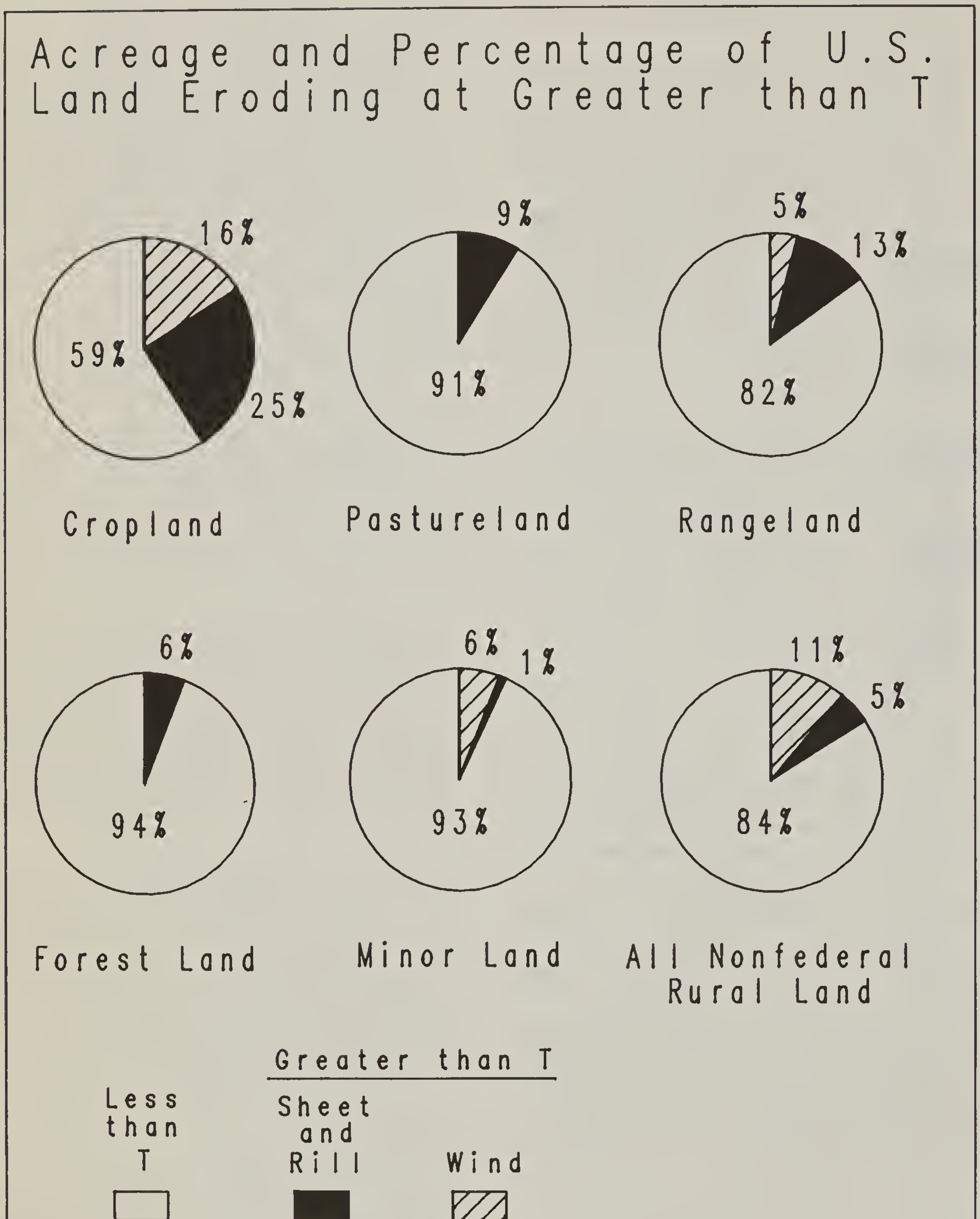
1/ USDA, Science and Education Administration. 1978. Predicting rainfall erosion losses. Ag. Handbook No. 537.

To help farmers and ranchers develop resource management systems that take into account differences in erosion hazard on different soils, soil scientists have assigned a "soil loss tolerance" or "T-value," which serves as a goal in planning. For cropland, pastureland, and forest land, currently-assigned T-values range from 1 to 5 tons per acre annually. On rangeland soils, which are generally thinner and more fragile, currently-assigned T-values do not exceed 2 tons per acre annually. Tolerance values consider in a general way the long-term effects of erosion on fertility, tilth, structure, and water-holding capacity. Figure 18 shows the percentage of land eroding at rates greater than tolerance.

Currently-assigned tolerance values will be changed as soil scientists learn more about the relationships between soil properties and erosion processes. The 5-ton limit on tolerance values is based partly on the observation that conditions permitting sheet and rill erosion at more than 5 tons per acre also create a severe hazard of gullying and that, at rates greater than 5 tons per acre, so much soil is moving that damage to the crop or offsite sediment delivery is probable. 2/ Some researchers using computer simulation have suggested that annual erosion rates greater than 5 tons per acre would not affect productivity on many deep soils and that higher tolerance values should be assigned to such soils. On the other hand, results of computer simulations indicate that some soils in "e" subclasses east of the Mississippi River, excluding the coastal plains of the Southeast, could begin to lose productivity within 100 years even if average annual rates of sheet and rill erosion were less than tolerance. About one-half of such cropland on the West Coast could also lose some productivity.

2/ Paschall, A.H., A.A. Klingebiel, W.H. Allaway, W.H. Bender, W.W. Carpenter, and L.M. Glymph. 1956. Committee report: Permissible soil loss and relative erodibility of different soils. USDA ARS and SCS, Washington, D.C.

Cropland: Where Is Erosion Causing Damage?



Less than T	Sheet and Rill	Wind	
(million acres)			
248	106	67	Cropland
122	11	<1	Pastureland
331	51	20	Rangeland
370	23	<1	Forest Land
50	8	2	Minor Land
1121	199	89	All Nonfederal Rural Land

Source: USDA-SCS, 1982 National Resources Inventory

Figure 18.--Acreage and percentage of rural nonfederal land eroding at greater than T (1982 NRI). For additional data, see appendix tables 10, 17, 18, 19, 20, 21, and 22.

Erosion is the major limitation to use of cropland. Nearly 52 percent of cropland is classified in the "e" subclasses of USDA's land capability classification system, meaning that erosion is the major hazard or limitation to use of the soil as cropland. Erosion is also a hazard on some cropland in other subclasses. 3/

To protect the productivity of their land, farmers need to know where erosion is causing damage and also where erosion is likely to cause damage if the operator changes land use or management. They need information on both the current erosion rates and the erodibility of their land. Figure 19 shows that information at the regional level. USDA soil conservationists use similar information for specific fields in helping farmers design conservation plans.

As the figure shows, erosion rates, susceptibility to erosion damage, and loss of productivity are not necessarily closely related, and the relationships vary among regions. In half of the regions, computer simulation of erosion's effects indicates that the acreage losing measurable amounts of productivity exceeds both the acreage classified as highly erodible and the acreage that was eroding at high rates -- twice tolerance or more -- in 1982. In the Northeast, for example, more than 40 percent of the cropland is classified as "highly erodible." Because many farmers are using management systems that provide considerable protection, less than 20 percent of the cropland is eroding at twice tolerance (T) or higher and another 10 percent is eroding at rates between 1 and 2 T. Because the majority of soils in the region are shallow, however, computer simulations indicate that, under 1982 management, two-thirds of the cropland in the region would lose at least 5 percent of its productivity within 100 years. Much of the land projected to lose productivity has erosion rates near or below the currently-assigned tolerance.

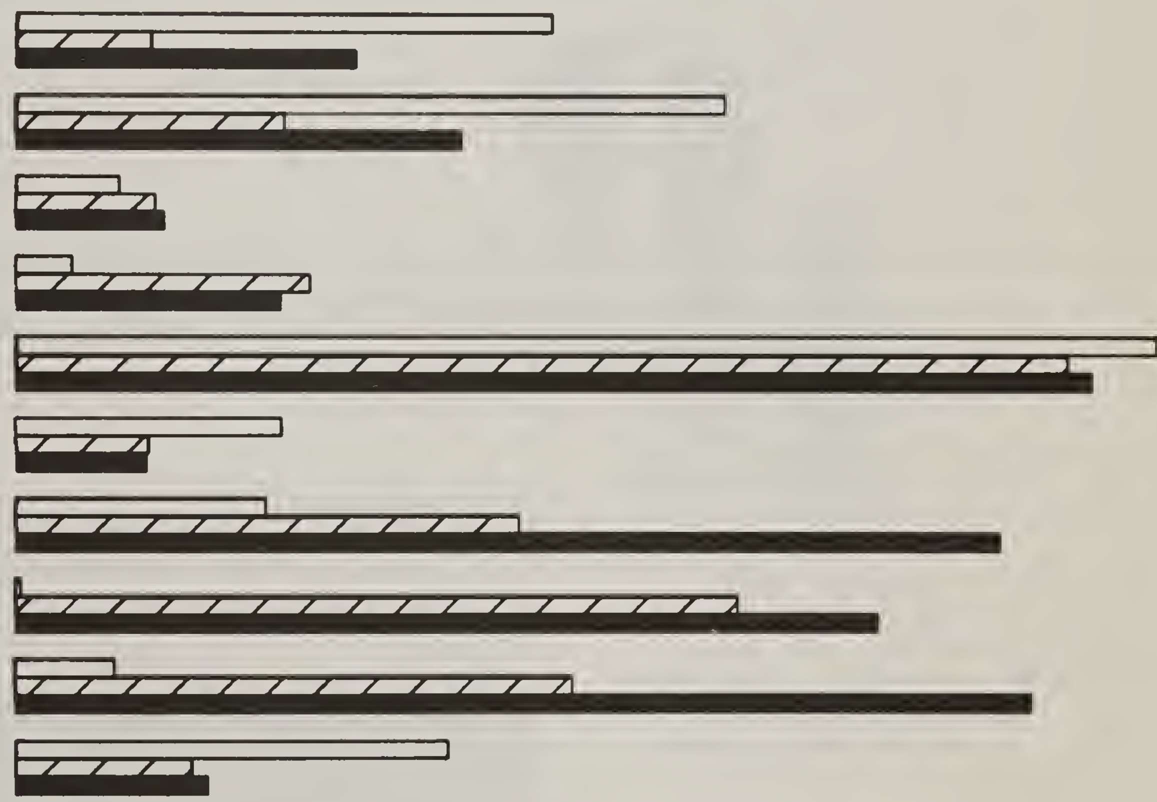
3/ The classes and subclasses of USDA's land capability classification system are described in chapter 3 of this report.

In the other five regions, the acreage projected to lose productive capacity is less than the acreage of highly erodible land or of the acreage eroding at considerably more than tolerance. The Northern Plains for example, has about as many acres of total cropland and almost as many acres of highly erodible cropland as the Corn Belt. However, the Northern Plains has only

Erosion Problems on Cropland

- Total Cropland
- Highly Erodible
- Erosion Rate >2T
- Productivity loss >5 percent

Total Cropland	Highly Erodible	Erosion Rate >2T	Productivity loss >5 percent	
(million acres)				
17	7	3	12	Northeast
23	10	6	15	Appalachia
18	3	3	2	Southeast
44	6	6	1	Lake States
92	23	23	25	Corn Belt
22	3	3	6	Delta States
93	21	11	5	Northern Plains
45	19	16	<1	Southern Plains
43	22	12	2	Mountain
23	4	4	9	Pacific
421	118	87	77	Total



"Erosion >2T" means that the soils had either sheet and rill erosion or wind erosion rates greater than twice the estimated soil loss tolerance under existing management, according to the 1982 National Resources Inventory.

"Highly erodible" cropland has an erodibility index (EI) of 8 or greater. The EI is calculated by multiplying together the erosion equation factors that represent soil, topographic, and climatic conditions and dividing the product by the soil loss tolerance assigned to the soil.

"Productivity loss" is estimated by the Erosion/Productivity Impact Calculator. The model simulation shows productivity loss on the soils in the RCA/EPIC soils data base, which includes soils that are in the "e" subclasses of the capability classification system and in classes VIs, VIIs, and VIII and were planted to major crops in 1982.

Figure 19.--Highly erodible cropland, and cropland eroding at damaging rates, by region.

about half as many acres eroding at high rates as the Corn Belt and only about one-fifth as many acres that are projected to lose as much as five percent of their productivity within 100 years under 1982 management.

These regional variations in the relationship among the data result primarily from differences in the crops and types of farming operation typical of the regions.

Excessive Erosion

On about 173 million acres (40 percent) of the Nation's 421 million acres of cropland, either sheet and rill erosion or wind erosion is greater than the currently-assigned soil loss tolerance (fig. 20). A major part of all erosion occurs on that land; slightly less than 70 percent of the tons of soil moved by sheet and rill erosion and 80 percent of the soil moved by wind is moved on that 40 percent of cropland (appendix table 17).

The region with the largest acreage of soils eroding at more than soil loss tolerance is the Corn Belt. The regions with the highest percentages of their cropland eroding at more than tolerance, however, are the Mountain States and the Southern Plains, where sheet and rill erosion or wind erosion exceeds tolerance on more than half the cropland.

The acreage of cropland eroding at rates greater than tolerance includes 116 million acres of land in the "e" subclasses and 57 million acres of land in other subclasses or in class I. For the Nation as a whole, average sheet and rill erosion rates and wind erosion rates on cropland exceed tolerance on land in capability classes IV, VI, and VII (appendix table 11). Since land in class IV is not suited to continuous cultivation and land in higher classes generally is not suited to cultivation, the high erosion rates are not surprising. Cropland in classes VI and above makes up only 3 percent of the Nation's cropland, however. Most land eroding at more than tolerance is in classes IV and better.

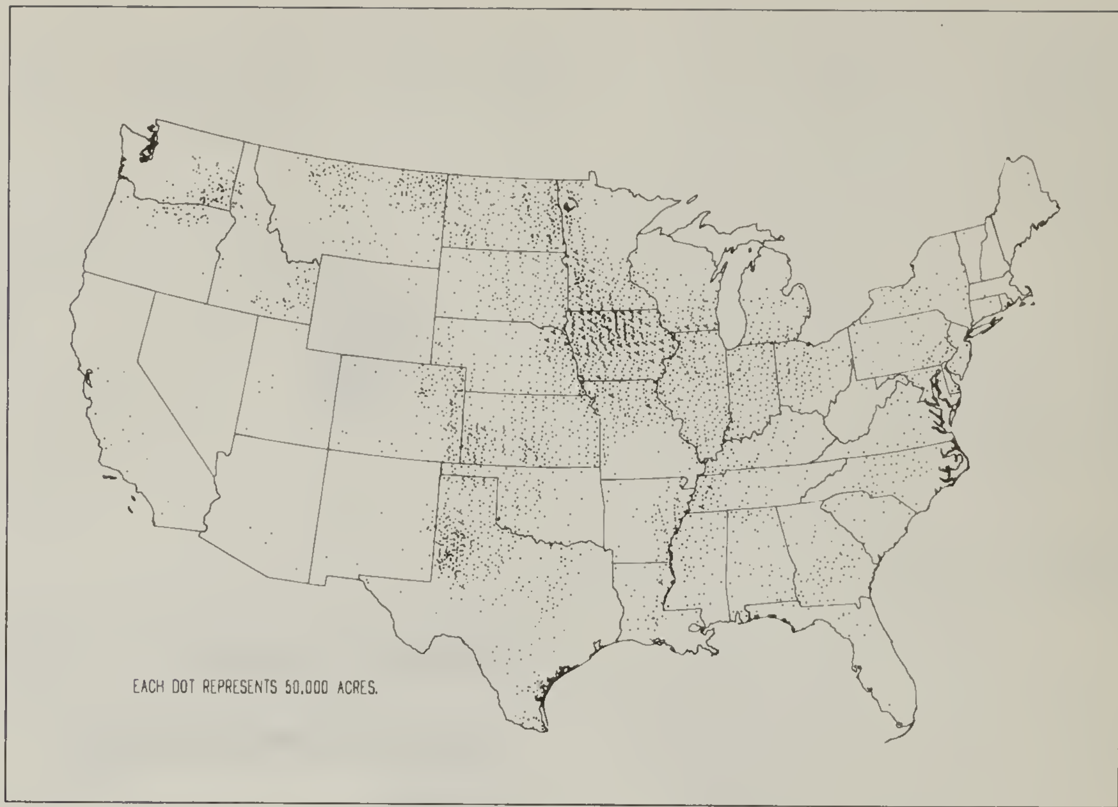


Figure 20.--Cropland where sheet and rill erosion or wind erosion is greater than T. For more complete data, see appendix table 10. The dot pattern is computer generated and does not show exact sites within a state.

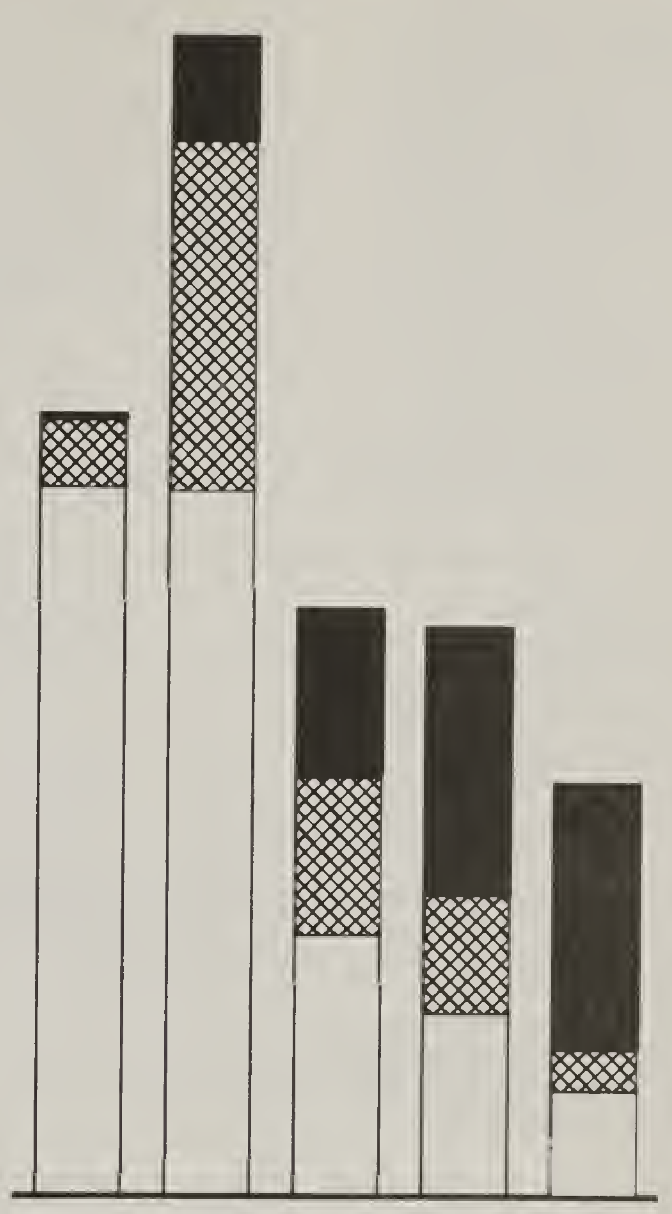
Figure 21.--Ephemeral gully erosion. This erosion is not counted in estimates of sheet and rill erosion and therefore is not considered in damage estimates given elsewhere in this report. Nor is it considered in assigning the EI of a soil.

Reducing Cropland Erosion: Indexing Identifies Excessive Hazards

USDA has developed a classification system using tolerance values and the factors of the erosion estimation equations to rate the susceptibility of soils to erosion damage. This index, the "EI," indicates the probability that the soil will be damaged by erosion. It is thus a more precise tool for identifying soils on which erosion control efforts should be focused than is provided by either the land capability classification system or estimates of current or potential erosion rates based on the erosion equations alone. 4/ The EI, however, does not take into account the effects of ephemeral gully erosion or classic gully erosion (fig. 21).

The EI is derived by dividing the physical and climatic factors (the RKLS factors of the Universal Soil Loss Equation or the CI factors of the Wind Erosion Equation) by the tolerance value assigned to a soil. (These equations are explained in chapter 13.) This procedure provides an index tying a soil's inherent erodibility to its susceptibility to damage caused by erosion, which makes it possible to compare the effects of erosion on different soils. For example, two soils for which RKLS equals 50 would each erode at a rate of 50 tons per acre per year if they were continuously in clean-tilled fallow. If one soil were deep and had a tolerance value of 5 tons per acre, that 50 tons would represent a rate of 10 times tolerance value. The soil would have an index of 10. If the other soil were shallow and had a T value of only 3, the 50 tons would represent a rate of more than 16 times the T value; that soil would have an index of 16. If both soils were managed in the same way, the second would be damaged more quickly than the first soil. If cultivated for the same number of years under the same crop and management, it would be more severely damaged than the first.

Using the EI values, soils can be grouped according to their likely



EI	<2	2-5	5-8	8-15	>15	Total
Erosion			Million Acres			
<T	85	85	31	22	13	236
T-2T	8	42	19	14	5	88
>2T	<1	12	20	32	32	96
Total	94	139	70	68	50	421

The EI is calculated by multiplying together the erosion equation factors that represent the soil, topographic, and climatic conditions of the site and dividing by the soil loss tolerance assigned to the soil.
"EI" < 2" means indexes for both sheet and rill erosion and wind erosion are less than 2.
For other classes, soils are classified on the basis of the higher of the two indexes.

Source: USDA-SCS, 1982 National Resource Inventory

Figure 22.--Erodibility Index "EI" and erosion rates. Classification is based on both sheet and rill erosion and wind erosion. A soil's index for one type of erosion is generally greater than the other; see appendix tables 13, 15, and 16.

4/ Appendix table 14 shows the relation between capability classification and EI.

response to erosion (fig. 22). Soils with a low EI are very slightly susceptible to damage; farmers who wish to crop them safely have a wide range of alternatives available. Soils with a high EI are very highly susceptible to damage and are quite difficult to protect if used as cropland. Soils in intermediate classes can be cropped safely if conservation is applied, but adequately protecting them gets harder as the index increases because there are increasingly fewer crop and management choices that would provide adequate protection (table 4).

Some soils don't need much protection. Soils with a low index (fig. 23) could not erode at a rate greater than twice the tolerance value even in continuous clean-tilled fallow. Because most crops will provide sufficient cover for enough of the year to reduce erosion to half the rate that would occur if there were no crop or other cover on the soil, these soils need very little additional protection against sheet and rill or wind erosion other than that provided by the growing crop. This 22 percent of cropland can safely be used indefinitely for crop production.

Conservation practices are generally not needed on these soils to prevent damage from either sheet and rill or wind erosion. About 91 percent of the cropland that is very slightly susceptible to erosion damage is eroding at less than T. That doesn't mean, however, that no conservation is needed at all. Grassed waterways may be needed to remove excess water even in some very gently sloping fields. Terraces may be needed to conserve water rather than soil. Drainage systems may be needed to prevent salinization from reducing productivity. Grass field borders and other measures may be needed to trap sediment if runoff from the field delivers sediment directly to a sensitive waterway.

Some soils are almost impossible to protect. Cropland that is "highly erodible" (fig. 24) could erode at rates 8 times the tolerance value or more if it were bare of cover. Cropland that is very

Figure 23.--Cropland with "EI" less than 2 (1982 NRI). For more complete data, see appendix table 12. The dot pattern is computer generated and does not show exact sites within a state.

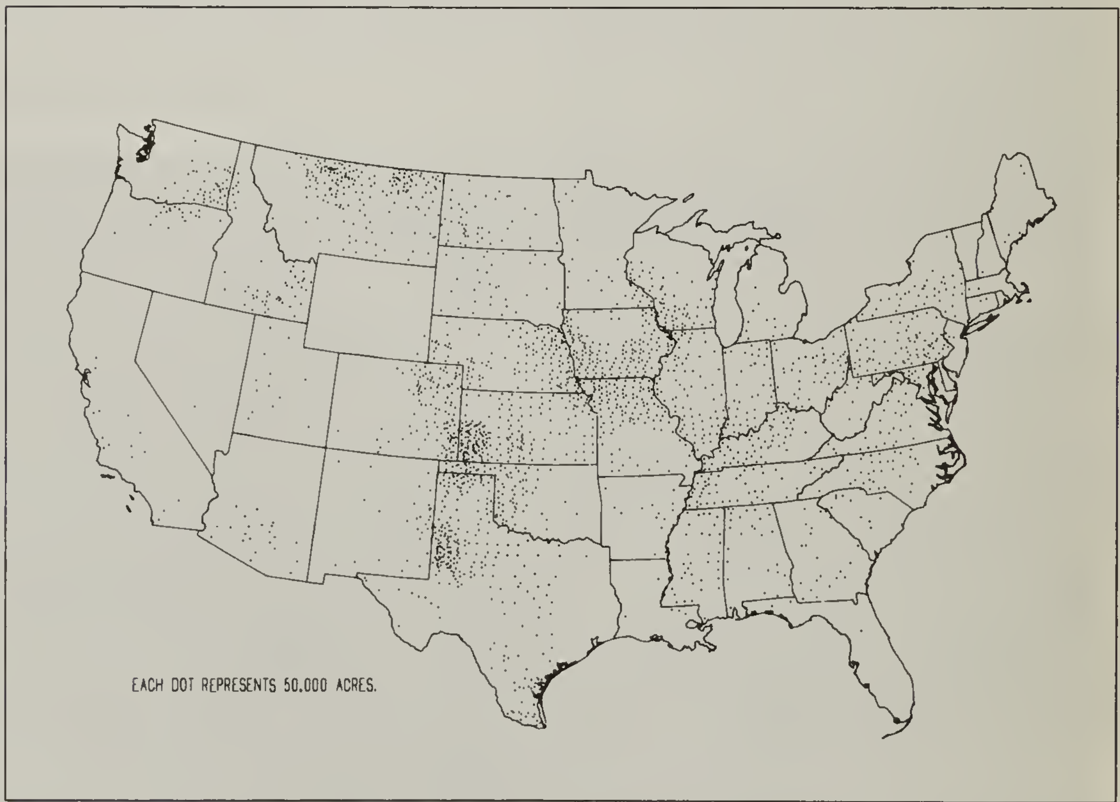


Figure 24.--Cropland with "EI" greater than 8 (1982 NRI). For more complete data, see appendix table 12. The dot pattern is computer generated and does not show exact sites within a state.

highly erodible could erode at 15 times the tolerance value or more if in continuous clean-tilled fallow. There are very few crop and tillage choices that will adequately protect these soils if they are used as cropland.

In 1982, 50 million acres of "very highly erodible" land were cropped. Three-fourths of these acres were eroding at more than tolerance and 64 percent was eroding at more than two times tolerance.

More than two-thirds of the cropland classified "very highly erodible" are highly susceptible to damage from sheet and rill erosion. Iowa and Missouri together have one-fourth of all the cropland that is very highly susceptible to damage from sheet and rill erosion (RKLS/T greater than 15). Thirty percent of all cropland that has a very high wind erosion index is in Texas.

Table 4.--Conservation management and practices needed to protect soils against damage resulting from sheet and rill erosion

Susceptibility to erosion damage	"Erodibility Index" (RKLS/T)	Treatment level required (CP)	Conservation management practices
Very slight	0 - 2	0.5 or greater	Conventional farming techniques generally adequate to control sheet and rill erosion and maintain productivity.
Slight	2 - 5	0.5 to 0.2	Practices needed may include maintenance of 30 percent cover of crop residue, contouring, or a combination of the two.
Moderate	5-8	0.2 to 0.125	Practices needed include maintenance of 30 to 50 percent cover of crop residue, contouring, terraces, contour strip-cropping, or some combination.
High	8 - 15	0.125 to 0.067	Practices needed generally include an intensively applied combination of two or more practices including maintenance of greater than 50 percent cover of crop residue, contouring, terraces, contour strip-cropping, and sod-based crop rotations.
Very high	15 and greater	less than 0.067	Permanent conversion to sod or trees, or long rotations with several years of sod.

The Universal Soil Loss Equation is: A = RKLSCP, in which A is the estimated soil loss. The first four factors (R, K, L, and S) represent the conditions of climate, soil, and topography existing at a site. The last two factors, C and P, estimate the degree to which use and management of the soil reduce erosion. Consequently, the value of CP must decline in reverse ratio to the rise of RKLS, if soil loss (A, the product of the whole) is to be held to a tolerable level. A more detailed explanation is given in chapter 13 under "Estimating Erosion."

How Much Cropland Productivity Is Eroded Annually?

Quantifying erosion damage is difficult. Erosion reduces yields when it is severe. Yield reductions of up to 50 percent have been observed in crops grown in eroded soil as compared with those on slightly eroded soils. Generally, however, only a very small amount of soil is moved in any given year. The resulting annual loss in productivity is so small that it is hidden by differences in the weather or in the management farmers apply from year to year.

In many soils, yields may not appear to decrease even if erosion is excessive because the farmer has switched to improved, more productive varieties of crops or is applying more fertilizer or controlling pests more effectively. Erosion may be reducing the increase that these improvements produce; that is even harder to measure than slight real decreases. Farmers may become aware of erosion damage only when erosion has so severely reduced the soil thickness that technology can no longer give increased yields.

Researchers are using computer technology to overcome some of the difficulties in studying erosion on field plots. The computer can rapidly simulate the effects of many years of erosion on many kinds of soil under various climatic conditions and management systems.

Figure 25 summarizes the results of one computer simulation of erosion that was developed for this appraisal. 5/ The simulation was made using the Erosion/Productivity Impact Calculator (EPIC) and Erosion/Productivity Index Simulation (EPIS) system. 6/ The figure shows the effects of sheet and rill erosion on 220 million acres of cropland in subclass "e" planted to major crops, assuming 1982 conditions. It also includes the soils in classes VIs, VIIs and VIII used to grow major crops. Data were not available to display in a similar form either wind erosion losses or sheet and rill erosion losses on the remaining 200 million acres of the Nation's cropland.

Figure 25.--Estimated loss of productivity in 100 years as a result of sheet and rill erosion, by major land resource area. See appendix tables 24 and 27.

5/ Putman, John, P.T. Dyke, and Glen Wistrand. 1986. The erosion productivity index simulator model. U.S. Department of Agriculture, Economic Research Service. Temple, Texas.

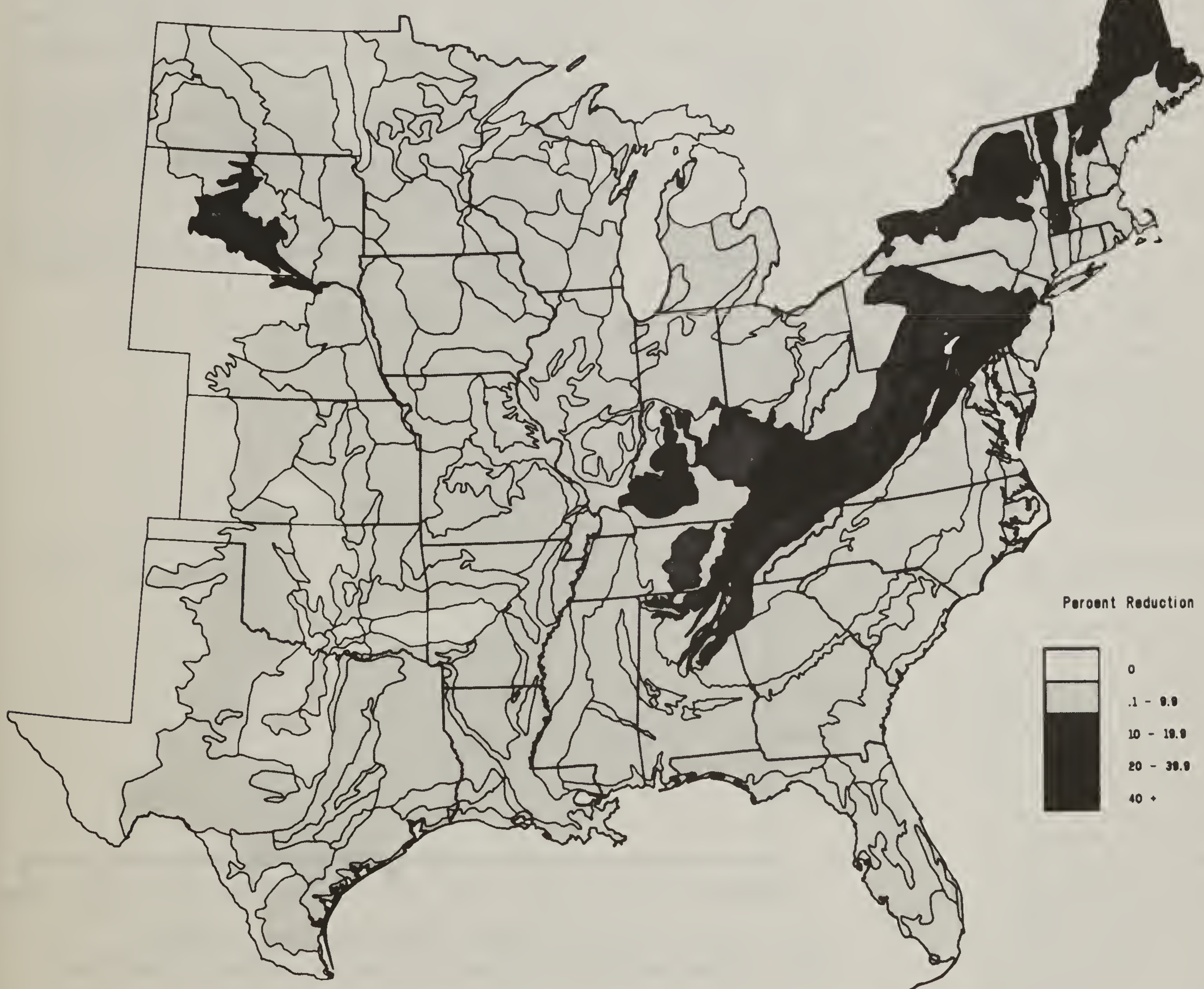
Williams, J.R., K.G. Renard, and P.T. Dyke. 1983. EPIC: a new method for assessing erosion's effects on soil productivity. J. Soil and Water Cons. 38(5):381-383.

Williams, J.R., C.A. Jones, and P.T. Dyke. 1984. A modeling approach to determining the relationship between erosion and soil productivity. Trans. of the Am. Soc. Agricultural Engineers, 27(1):129-144.

The model's estimates of productivity loss are greatest for the Northeast and Appalachia because many of the soils in these areas developed from highly weathered sandstone and shale and are, therefore, infertile; are shallow over bedrock or have fragipans; are on undulating to very steep topography; and have been cultivated since at least the early 19th century.

The most severe losses shown on the West Coast are also on shallow, steep soils. For this analysis, only soils on which major crops are grown were included; the figure does not imply that loss of productivity would be high on California soils planted to high-value specialty crops such as citrus and nut trees or vegetables.

Percent Reduction In Crop Productivity, 100TH Year Yield Loss, Resulting From Sheet And Rill Erosion, Reflecting The Average Of All Crops, Tillages And Conservation Practices On Cropland In 1982



6/ The EPIC/EPIS system models are described in the "Methods" chapter of this report.

The data for the figure were produced by choosing a representative soil for each of the "e" subclasses and for classes VIs, VIIs, and VIII in each major land resource area shown in the map. The estimates shown do not include loss of productivity on class I soils or soils in subclasses "w" and "c" and most soils in subclass "s". In a few cases, the figure may indicate lower losses than are actually occurring in a major land resource area if a considerable portion of the excessively eroding soils in the area are classified other than "e."

The EPIC/EPIS analysis estimates that 100 years of sheet and rill and wind erosion, under 1982 management conditions, would reduce productivity nationally by nearly 3 percent (table 5). The projected national percentage of loss is low because many soils are not losing any productivity under current management. Productivity loss is concentrated on soils eroding at several times the tolerance value or on very fragile soils where even slight erosion results in significant yield reductions. On some of these specific soils, loss of productivity is projected to be quite high. Loss of productivity after 100 years is projected to be as high as 60 percent along the Central California Coast Range and as high as 50 percent in the Great Valley of Virginia.

For the analyses reported here, the EPIC/EPIS system simulated a 100-year period. A century is a short time in the existence of a soil--or a society. Some soils in the eastern part of the Nation have been cultivated for as much as 300 years. A 100-year run can be misleading as an indicator of the long-term effects of erosion; longer simulations produce quite different results. On a typical Midwestern soil, for example, EPIC indicates very little loss of productivity over the first 100 years because only slight reductions in yield are estimated regardless of the degree of conservation effort. But if the same conditions are simulated for a longer period, even that deep fertile soil will become totally unable to support a crop if erosion control practices are not applied (fig. 26).

Table 5.--Estimates of percent loss of productivity resulting from erosion in 100 years, by farming region

Farming region	Sheet and rill	Wind
Northeast	7.1	*
Lake States	0.9	0.7
Corn Belt	3.5	*
Appalachia	4.7	*
Southeast	1.3	*
Delta States	1.6	*
Northern Plains	0.6	0.3
Southern Plains	0.2	2.1
Mountain States	0.4	1.4
Pacific States	2.3	0.2
United States	1.8	0.5

Modified USLE erosion rates assumed, on 421 million acres of cropland (1982 total).
* = less than 0.01 percent.
Analysis did not estimate productivity loss on cropland where sheet and rill erosion alone is less than tolerance and wind erosion alone is less than tolerance but the sum is greater than tolerance.
Source: Erosion/Productivity Impact Calculator (EPIC).
See appendix tables 24 and 27 for further data.

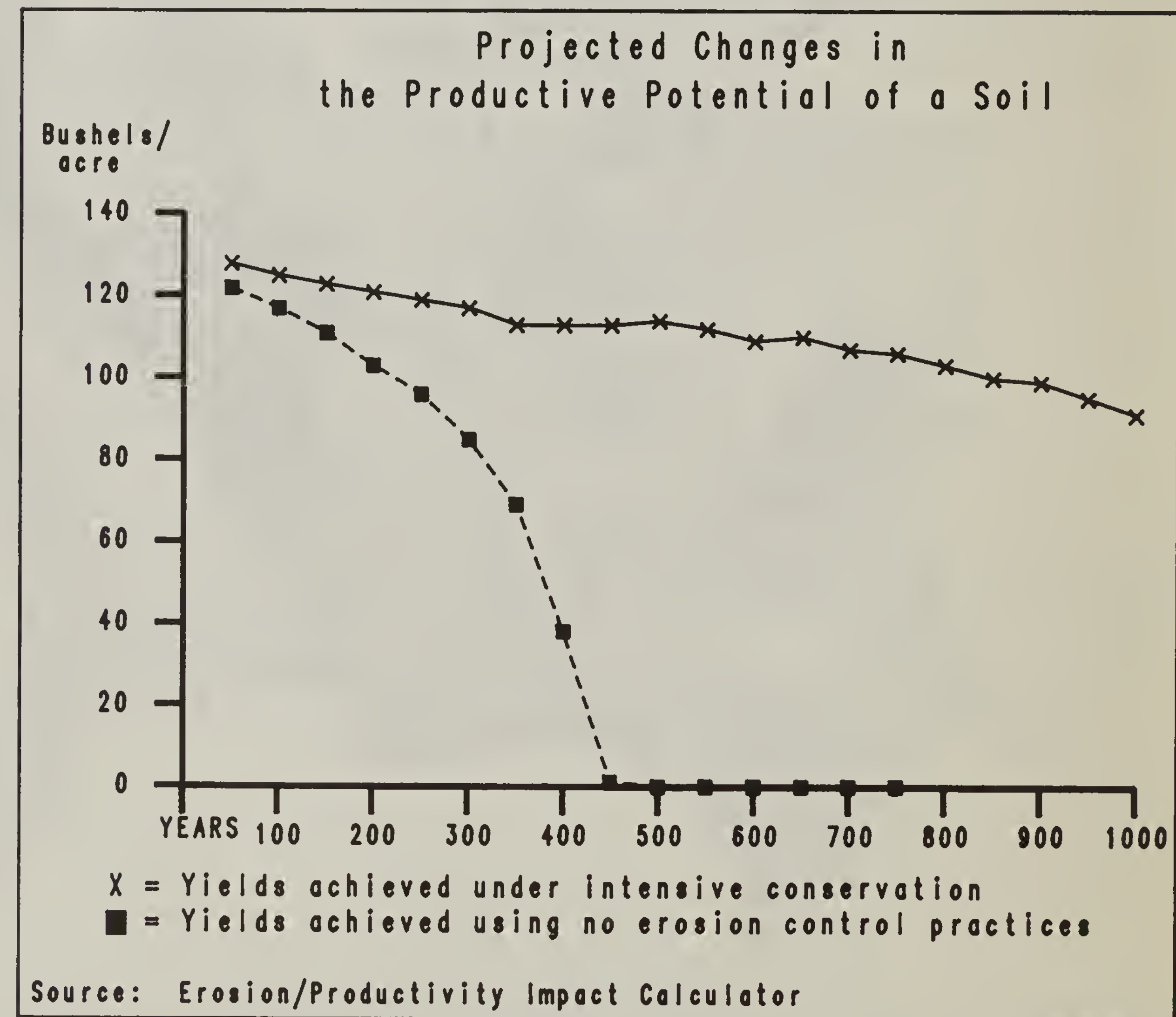


Figure 26.--Decrease in yield resulting from erosion of a typical midwestern soil.

Figure 25 indicates the soils' loss of productivity but not the effect the loss might have on the production of an area or a state, because the estimates make no distinction between loss in an area where cropland is an important land use and in areas where there are very few acres of cropland. Table 6 shows EPIC's estimate of loss expressed as "equivalent acres" in each state. "Equivalent acres" are not the number of acres on which damaging erosion occurs (that information is shown in table 8). Rather, equivalent acres are the number of additional acres that would be needed, after 100 years of erosion, to match current production levels, assuming constant technology. Table 6 shows estimates for all of the Nation's 421 million acres of cropland. The greatest number of equivalent acres would be needed in the Corn Belt, where millions of acres used for growing feedgrains are projected to sustain moderate losses in productivity.

Table 6.--"Equivalent acres" 1/ required to replace productivity lost as a result of 100 years of erosion, by state

State	Acres (1,000) 2/		State	Acres (1,000) 2/	
	Sheet and rill	Wind		Sheet and rill	Wind
Iowa	617	*	Arkansas	47	*
Illinois	568	*	Michigan	47	0.1
Missouri	413	*	Texas	46	380
Indiana	389	0.3	New Jersey	42	*
Kentucky	358	*	Maine	28	*
Pennsylvania	333	*	West Virginia	25	*
Ohio	310	*	Louisiana	15	*
New York	261	*	North Dakota	13	2
Nebraska	246	19	South Carolina	12	*
California	235	3	Montana	11	108
Tennessee	190	*	Utah	6	0.9
Washington	139	76	Oklahoma	5	19
Virginia	115	*	Vermont	4	*
Wisconsin	114	0.1	Connecticut	4	*
Mississippi	109	*	Massachusetts	4	*
Minnesota	103	2	Florida	3	*
Alabama	92	*	Delaware	1	*
North Carolina	89	*	New Hampshire	1	*
Maryland	82	*	Colorado	*	128
Idaho	71	66	Rhode Island	*	*
South Dakota	68	50	Wyoming	*	3
Kansas	59	43	New Mexico	*	10
Georgia	53	*	Nevada	*	31
Oregon	49	9	Arizona	*	*

1/ Equivalent acres are the number of additional acres needed, after 100 years of erosion, to produce the amount of crops currently produced. They are calculated by multiplying the percentage of productivity loss by the acres of cropland in a major land resource area (MLRA) and then by an index of productivity that considers both the acreages of major crops in the MLRA and the average yield for each crop.

2/ Data base includes only cropland in e subclasses and in classes VIs, VIIs, and VIII.

* Less than 100 acres.

For additional data, see appendix tables 25 and 28.

Source: Erosion/Productivity Impact Calculator--Erosion/Productivity Index Simulator.

Controlling Cropland Erosion: How Much Are We Accomplishing?

The conservation practices on the land in 1982 were significantly reducing erosion damage. Figure 27 shows EPIC/EPIS estimates of the percentage loss in productivity in each major land resource area that would result from sheet and rill erosion over 100 years if no conservation practices were applied. Comparing this map to fig. 25 shows where current management is having the greatest success in reducing erosion.

"No conservation" means that conventional tillage was projected on all fields and no supporting practices--contouring, strip-cropping and terraces--would be in place. Because the crops and rotations grown are the same for both alternatives, however, the "no conservation" estimates do include the effects of any conservation rotations in place in 1982.

Table 7 shows the value of the soil productivity maintained by practices installed to control sheet and rill erosion on subclass e cropland in 1982, as estimated by the EPIC/EPIS system. The table shows estimates of the loss caused by sheet and rill erosion expressed as "gross product loss." "Gross product loss" is calculated by multiplying the equivalent acres by $198, which is the national average value of production of the major crops (yield times normalized prices). The table shows the value of the productivity reduction estimated with "no conservation" applied and that estimated for the crops and rotations, conservation practices, and erosion rates recorded in the 1982 NRI. The difference between the two estimates is one measure of the onsite benefits of present conservation efforts. Data are not available at present to compare "no conservation" and 1982 conservation measures for wind erosion control.

The table is not a full accounting of all the benefits of erosion control. The table shows only the estimated value of the permanent loss of productivity that would result in the absence of conservation practices. It does not include the cost of the additional fertilizer and lime that would be needed on some soils to compensate for lost fertility, nor does it attribute any value to crop damage prevented by the conservation measures.

Table 7 and figure 27 show that, in monetary terms, the greatest effect from controlling sheet and rill soil erosion occurs in the land resource regions that account for most of the acreage in Kentucky, Tennessee and West

Figure 27.--Estimated loss of productivity by the 100th year, resulting from sheet and rill erosion, if no conservation practices were in place.

Virginia and parts of Indiana, Ohio, and Pennsylvania. In these regions many of the soils tend to be shallow to moderately deep, are on undulating to steep slopes, and have suffered excessive soil loss over the period that the land has been cultivated. Additional sheet and rill erosion will severely inhibit the ability of the soils to maintain crop productivity, thus costing the farmer in lowered yields, not to mention additional fertilizer and lime added as soil amendments.

Percent Reduction In Crop Productivity, 100TH Year Yield Loss, From Sheet And Rill Erosion, Straight Row Spring Plow Tillage With No Conservation Practices

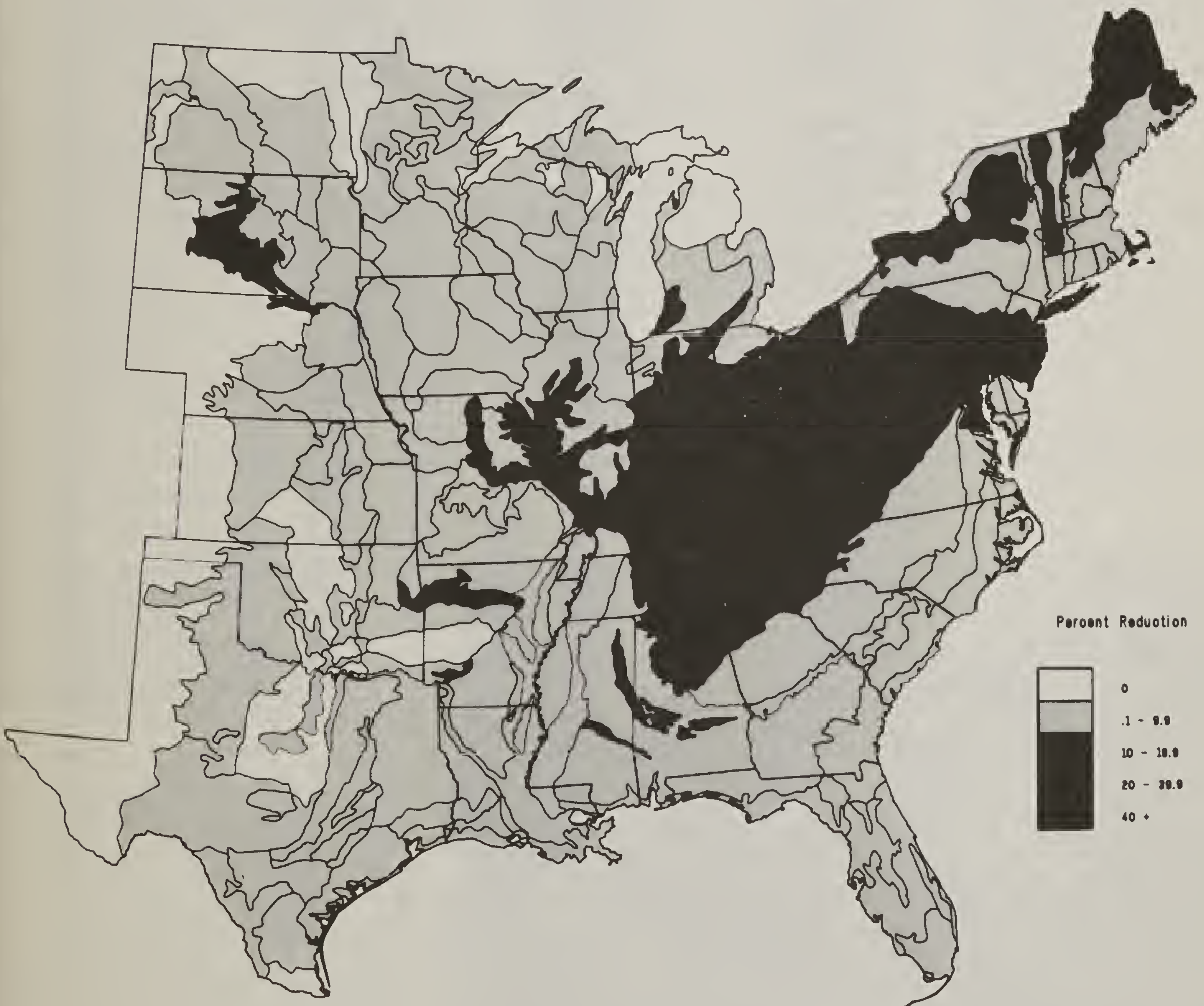


Table 7.--Present value of productivity maintained by sheet and rill erosion control practices in place in 1982, by state

State	Net present value of "Gross product loss" over 100 years		Net present value of productivity maintained by 1982 conservation practices
	"no conservation"	1982 conditions	
	(million dollars)		
Ohio	820	360	460
Pennsylvania	818	387	431
Kentucky	799	416	383
Montana	335	12	322
Indiana	770	453	317
Nebraska	573	286	287
Washington	425	162	263
California	503	274	230
Iowa	937	718	220
Tennessee	434	221	213
Wisconsin	325	132	192
Maryland	245	96	149
Illinois	807	661	146
West Virginia	168	29	140
Kansas	200	69	131
South Dakota	204	79	125
Virginia	254	134	120
Alabama	212	108	105
Oregon	150	57	93
Texas	146	54	93
Missouri	572	480	92
Mississippi	213	126	86
North Carolina	171	103	68
Oklahoma	69	6	63
New York	303	245	59
Georgia	120	61	58
Wyoming	46	0	46
New Jersey	85	49	37
Michigan	89	55	34
Minnesota	149	120	29
South Carolina	37	14	23
Maine	53	32	21
Florida	23	3	20
Nevada	18	0	18
Vermont	19	5	14
Idaho	83	69	14
Delaware	15	1	14
North Dakota	28	15	13
Arkansas	67	55	12
Colorado	12	.5	12
Connecticut	15	5	10
Utah	14	7	7
New Mexico	7	0	7
Massachusetts	12	4	7
New Hampshire	8	.8	7
Louisiana	23	17	6
Rhode Island	.6	.3	.3
Arizona	.02	0	.02
United States	11,378	6,182	5,197

Net present value calculated at 4 percent over 100-year period.
See page 38 for definitions of "gross product loss" and "no conservation".
Source: Erosion/Productivity Impact Calculator--Erosion/Productivity Index Simulator.

Table 8.--Cropland projected to lose more than 5 percent of its current productivity after 100 years of sheet, rill and wind erosion, assuming 1982 management

Region and state	Productivity loss >5 percent	Region and state	Productivity loss >5 percent	Region and state	Productivity loss >5 percent
	(1,000 acres)		(1,000 acres)		(1,000 acres)
NORTHEAST		SOUTHEAST		NORTHERN PLAINS	
Connecticut	0	Alabama	1,995	Kansas	0
Delaware	74	Florida	0	Nebraska	236
Maine	487	Georgia	208	North Dakota	0
Maryland	882	South Carolina	12	South Dakota	5,138
Massachusetts	41	Region	2,215	Region	5,374
New Hampshire	4				
New Jersey	718	DELTA STATES		APPALACHIA	
New York	4,607	Arkansas	2,499	Kentucky	5,792
Pennsylvania	4,574	Louisiana	1,176	North Carolina	2,573
Rhode Island	0	Mississippi	2,034	Tennessee	4,227
Vermont	154	Region	5,709	Virginia	2,275
Region	11,541			West Virginia	395
		SOUTHERN PLAINS		Region	15,262
LAKE STATES		Oklahoma	105		
Michigan	1,203	Texas	0	PACIFIC	
Minnesota	0	Region	105	California	1,901
Wisconsin	0			Oregon	1,905
Region	1,203	MOUNTAIN		Washington	5,486
		Arizona	0	Region	9,292
CORN BELT		Colorado	0		
Illinois	5,610	Idaho	1,070		
Indiana	6,966	Montana	0	TOTAL	77,404
Iowa	2,017	Nevada	857		
Missouri	5,155	New Mexico	0		
Ohio	4,840	Utah	184		
Region	24,588	Wyoming	4		
		Region	2,115		

Source: EPIC

This resource management system includes contour stripcropping to protect the soil and grass filter strips to protect water quality in the adjacent stream.

Where Is Erosion Causing Damage?

Either of two indicators may be used to identify soils where erosion damage is a hazard--range condition or tolerance values. Range managers generally think that range condition is a better guide. 7/

Tolerance values assigned to rangeland soils are lower than those for most soils used as cropland because most rangeland soils are limited by shallowness of the root zone and severity of the climate. Tolerance values for rangeland vary from one-half ton to 2 tons per acre. Even so, most range managers think that the tolerance values assigned to most individual soils are too high to permit a high level of crop (climax vegetation) productivity to be sustained indefinitely.

If tolerance values are used as the indicators, about 70 million acres of nonfederal rangeland are eroding at damaging rates. Waiting until erosion exceeds tolerance is poor range management, however. On range in good or excellent condition, a vigorous stand of adapted native vegetation provides effective protection against even severe winds and occasional torrential rainstorms. Erosion does not become visible on rangeland until the vegetation has been severely damaged. Reestablishing range vegetation under unfavorable climate and soil conditions requires years, if it is possible at all. During those years erosion continues to damage the fragile soil, further reducing the possibility that the range can return to its former productive state.

If range condition and trend are used as the primary indicators, and if we assume that all rangeland in less than good condition is susceptible to erosion damage, erosion is a potential problem on 249 million acres (61 percent) of nonfederal rangeland.

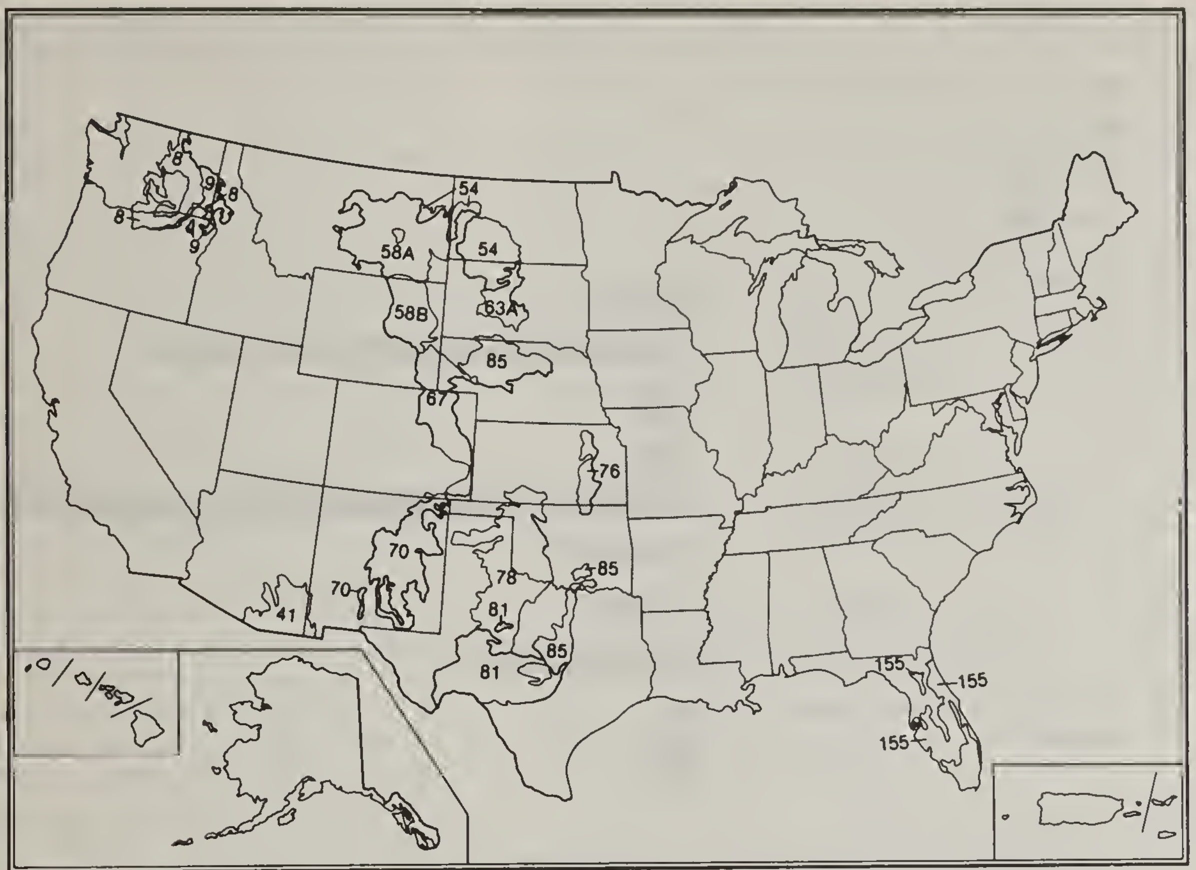
The relationship between range condition and erosion is apparent at the range site level. Table 9 shows this relationship for 16 randomly selected range sites in 14 states. In general, the data show increasing rates of erosion as range condition declines. With the exception of the Shallow Clay site in South Dakota, sites in excellent and good condition have little or no erosion problem. Sites in poor or fair condition generally have higher rates than sites in good or excellent condition, but they do not necessarily have high rates. Erosion may be slight on sites in poor condition if considerable cover exists, even if the cover is annuals or plants with little value as forage. In the long run, however, such sites are more susceptible to erosion because the cover is ephemeral and not dependable from year to year. No relation between condition class and erosion rate is apparent if data are aggregated to units larger and more varied than range sites.

Table 9.--Sheet and rill erosion, by range condition, selected major land resource areas and range sites

Range site	Major land resource area	Excellent #pts	Excellent Acres (100)	Excellent Erosion rate	Good #pts	Good Acres (100)	Good Erosion rate	Fair #pts	Fair Acres (100)	Fair Erosion rate
KS - Limy Upland	76	48	425	0.8	333	4,347	1.7	154	2,038	3.6
TX - Clay Loam	78	9	172	0.2	196	4,580	0.4	541	12,521	0.7
TX - Low Stony Hill	81	2	38	0.1	113	2,561	0.6	1,233	31,956	1.5
TX - Low Stony Hill	85				12	213	0.7	164	2,855	1.5
OR - Loamy, 12-14"	8	5	86	0.2	9	220	1.3	17	300	1.5
WA - Shallow, 15-19"	9	5	25	0.1	50	311	0.2	38	189	0.2
AZ - Loamy, 12-16"	41	2	65	0.0	31	2,310	0.4	38	3,903	0.5
SD - Shallow Clay	63A	35	1,306	2.8	260	10,526	3.1	67	2,343	4.1
NM - Loamy	70				30	3,179	1.0	83	5,126	1.3
ND - Shallow	54	20	510	1.3	137	2,908	0.6	35	811	1.8
NE - Sandy	65	111	6,508	0.5	419	29,749	0.6	113	6,530	0.5
CO - Loamy Plains #2	67				22	1,050	0.5	41	1,607	0.5
OK - Loamy Prairie	78	4	83	0.1	76	1,496	0.6	141	2,665	1.3
MT - Silty, 10-14"	58A	30	2,164	0.2	132	9,999	0.8	83	7,381	0.6
WY - Sandy, 10-14	58B	1	5	0.2	21	1,373	1.0	34	1,818	2.0
South FL Flatwood	155				20	279	0.4	260	4,473	0.0

Points (number) are the selected sample points surveyed in each condition class.

7/ See appendix table 22 for data on erosion rates in excess of T on rangeland. Range condition is discussed in chapter 5 of this report.



Major land resource areas are geographic areas that have relatively homogeneous patterns of soil, climate, water resources, land use, and type of farming.

A range site is a distinctive kind of rangeland that differs from other kinds of rangeland in its potential to produce native plants.

Poor			Not applicable		
#pts	Acres (100)	Erosion rate	#pts	Acres (100)	Erosion rate
36	501	5.4			
156	3,559	0.9	21	534	0.3
295	7,168	2.9	9	148	1.0
140	2,515	2.5	8	49	1.8
13	256	2.0			
50	586	0.6			
43	2,922	0.5	5	278	1.1
14	423	7.0			
11	1,460	1.6			
7	172	1.8			
17	941	1.4			
25	597	1.2	1	25	0.6
7	773	0.2			
1	6	0.3			
316	4,612	0.0	6	114	1.0

Erosion on Pastureland

Erosion is generally not a problem on well-managed pastureland. Healthy, productive vegetation provides protection against even severe storms. Erosion is greater than T, however, on more than 11 million acres of nonfederal pastureland (fig. 28). Two-thirds of all sheet and rill erosion on pastureland is occurring on less than 9 percent of the acreage; in fact, just 0.7 percent of pastureland is responsible for 46 percent of the tons of soil eroding in excess of T. Seven percent of pastureland is in capability classes VII and VIII, and on these soils erosion is a serious problem.

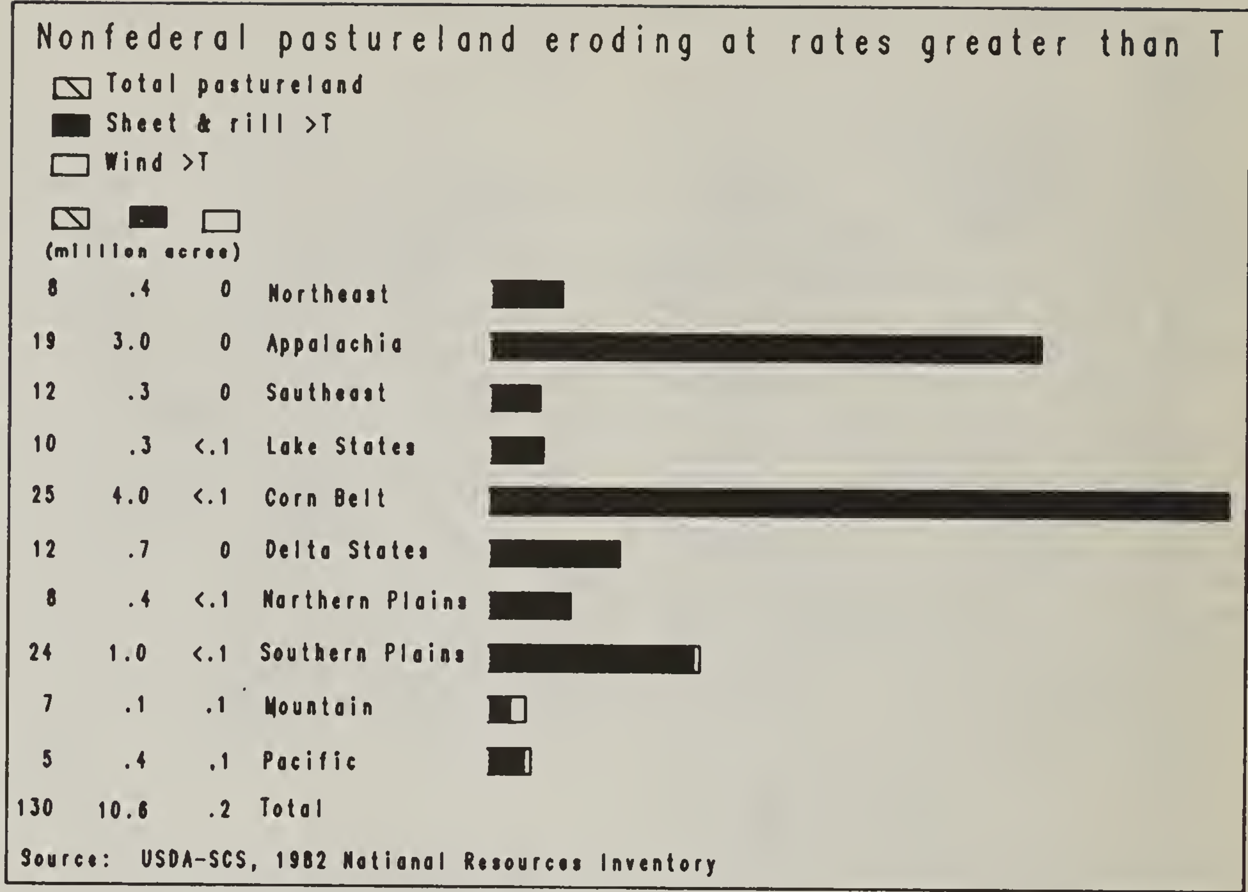


Figure 28.--Nonfederal pastureland eroding at rates greater than T (sheet and rill erosion). For more complete data, see appendix tables 18 and 20.

Erosion on Forest Land

Erosion is generally a problem on forest land only in areas where the cover has been disturbed by human activity. Activities related to timber and pulpwood harvesting increase erosion. Sheet and rill erosion rates exceed T on more than 23 million acres of nonfederal forest land (fig. 29). Most of that forest land is grazed. Nearly three-fourths of all sheet and rill erosion on forest land is occurring on less than 7 percent of the acreage. Wind erosion exceeds T on less than 1 million acres.

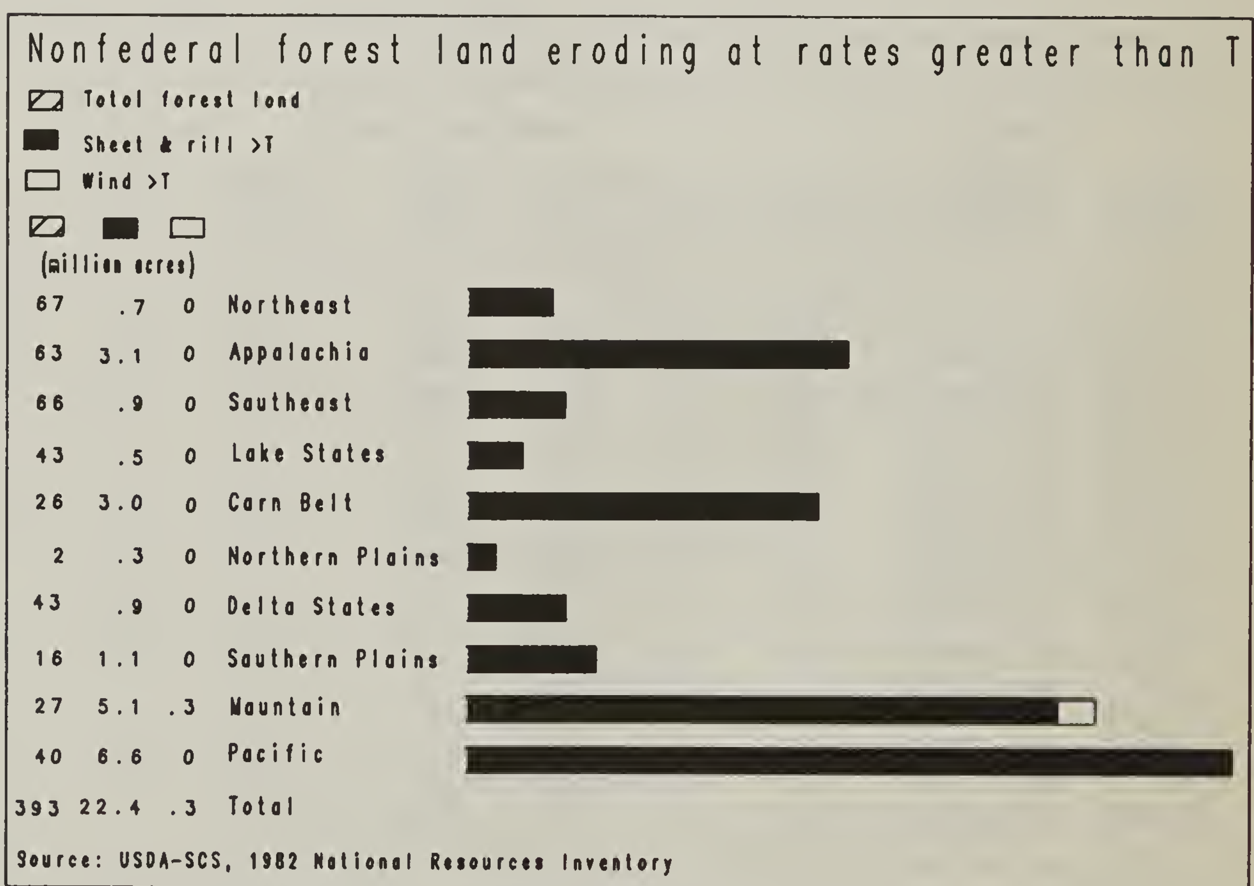


Figure 29.--Nonfederal forest land eroding at rates greater than T For more complete data, see appendix tables 19 and 21.

Why Do Farmers Adopt Conservation Practices?

If we could answer this question, we could develop strategies for persuading more farmers, ranchers, and other landusers to adopt conservation practices. Although we do not yet know all the answers, recent research in the area of adoption of soil and water conservation has provided useful information. We know, for example, that those who adopt conservation practices are likely to be well-educated, full-time farmers who participate in many organizations. We know that landusers who possess the "conservation ethic"--that is, those who are concerned about preserving the land for future generations--are also more likely to practice conservation, although other factors, such as their willingness to take risks, may intervene. Landusers who use conservation practices are generally owner-operators; their families participate in the operation, and they realize that they have erosion problems on their land. Although most of this research has involved farmers, it may be possible to expand these generalizations to include ranchers with similar characteristics.

These research findings are supported by SCS evaluations of agency programs and activities. A recent evaluation of the SCS Conservation Technical Assistance (CTA) Program, for example, shows that, in most areas, half of CTA planning assistance in 1983 was provided to those who had been conservation district cooperators for at least 3 years. Owner-operators received almost three-fourths of CTA direct assistance. Where SCS had redirected its activities to focus on the most critical problem areas, a higher proportion of assistance was directed to landlords, nonfarmers, and those who were not conservation district cooperators.

Sociological research indicates that we may need to develop special strategies if we are to persuade more farmers and ranchers to apply conservation systems. The research confirms that the American farming community (and therefore, the conservation program clientele) is less and less the homogeneous group of full-time family farmers that comprise the popular American image of "farmer," and more and more a heterogeneous group that includes corporate farmers, part-time farmers, professional farm managers, and absentee landowners. Each of these groups has unique values, needs, and attitudes that influence their conservation decisions. Recent studies have provided information that can help in developing more effective strategies. For example, studies indicate that:

o Farmers and ranchers should be viewed as a segmented, rather than a mass audience.

o Farmers and ranchers need personalized information and technical assistance that will help them increase their awareness and recognize erosion as a problem on their own land.

o Farmers and ranchers need information and technical assistance that will help them evaluate the economic impacts of proposed conservation systems on their operation.

o More use should be made of the mass media, especially farm magazines, for the dissemination of conservation information.

o The role of the various agencies involved in conservation should be clarified, common goals among the agencies firmly established, and a teamwork approach of public and private organizations at the local level emphasized.

o Implementation strategies and marketing approaches should be targeted to the needs, abilities, and attitudes of different clienteles.

o Obstacles to conservation (such as tradition, assumptions about costs, reluctance to take risks) should be identified and dealt with.

o The best mix of technical, educational, and financial assistance should be considered in relation to the socioeconomic characteristics of the local community members.

o Potential and existing networks among farmers, ranchers, and other land users should be used to help disseminate conservation information and to expand participation among a wide variety of local groups.

What Sociological Research Tells Us

In the 1960's, researchers generally tried to explain farmers' use or non-use of conservation on the basis of the characteristics of individuals, without reference to other influences that might affect their behavior. This was known as the social-psychological approach, and concentrated on such individual characteristics as age, education, attitude toward conservation, years of farming, and off-farm employment.

More recently, researchers have suggested that farmers' behavior must be viewed within the context of numerous social, economic, political, and environmental factors that influence their decisions. The following is a brief summary of major findings of current research.

Characteristics of Farmers.--Researchers have found considerable variation in the relationships between age and conservation behavior. Some studies have found that older farmers are more likely to be SCS cooperators; other studies have found no relationship between the age of the farmer and the use of conservation practices. Since none of these studies was longitudinal, it is not known, for example, whether older farmers have become co-operators when older, or whether innovative older farmers were also innovative younger farmers. Some studies indicate that the number of years of farming is positively related to use of conservation practices, at least in the early years of farming, while others show that more experienced farmers are more likely to rely on traditional tillage practices.

While age and experience do not appear to be closely related to application of conservation, there is apparently a clear and strong relationship between education and use of conservation practices. Highly educated farmers also are more likely to be aware of erosion problems.

Researchers have found that farmers who adopt and use conservation practices tend to participate in many organizations. Farmers who are employed off-farm are less likely to adopt and use conservation practices.

Attitudes.--Attitudes in four general areas have been examined in relation to use of conservation practices: stewardship, risk orientation, non-economic orientation toward farming, and attitudes toward government involvement.

Stewardship, or the belief that farmers have a moral obligation to protect natural resources, is highly associated with the use of conservation practices. However, at least one recent study has determined that other factors, such as economic returns, are far more influential in the adoption of practices.

Risk orientation, defined as the likelihood one will take chances, has been positively related to use of conservation practices. However, another study has found that farmers who were most concerned about environmental issues also were the least willing to take chances, and notes that risks associated with the adoption of conservation will probably have to be reduced before these farmers will use conservation practices.

Farmers who have a non-economic orientation toward farming (that is, those who place a high value on being their own boss) are more likely to use conservation practices and are significantly more concerned about soil erosion than other farmers.

Farmers have mixed attitudes toward government involvement in agriculture. On one hand, farmers generally do not support any type of legal pollution controls. Furthermore, if the economic situation for farmers worsens, they become even less supportive of government intervention that has a regulatory flavor to it. On the other hand, most farmers feel that government is responsible for funding conservation.

Farm Characteristics.--Researchers have also examined the relationship between the characteristics of the farm or ranch and the farmer's use of conservation practices. These characteristics include: size of operation, net income/farm sales, tenure, and farm specialization/diversification.

Most studies indicate that the larger the farm and the farm income, the greater the use of conservation practices. Farmers who own their own farms are more likely to use conservation practices, particularly when the practices are profitable.

Family participation in the farm operation also appears to be related to adoption of conservation practices. When families have common aspirations regarding the future of the farm, use of conservation practices is significantly higher. Family size is related to the number of practices used, as are the degree to which married couples share in farm decisions and the degree to which the family is involved in gathering farm-related information.

Research into the relationship between the degree of farm specialization/diversification and conservation practice use shows mixed results. One study found more specialized farms used significantly fewer practices and expended little effort in reducing soil erosion. Another found that, the more specialized a farm, the greater the number of practices used.

Environmental Factors.--Two factors must be considered in determining the effect the environment has on adoption of conservation practices: (1) actual soil erosion conditions, and (2) the farmer's perception of soil erosion conditions. Research findings are mixed, perhaps because of the variability in research techniques. Some researchers have calculated erosion rates on study farms using the Universal Soil Loss Equation (USLE); others have accepted the farmer's evaluation of erosion conditions.

Some studies using the USLE to evaluate erosion have found that erosion conditions do not explain behavior. In other words, farmers with the most severe erosion problems are not necessarily more likely to use more practices than farmers with less severe erosion problems. One study compared farmers' perceptions of their erosion problems with objective evaluations by SCS personnel over time. The study found that the evaluations of farmers and of soil conservationists differed considerably, but the differences decreased with intensified assistance. In 1978, only 1 percent of the farmers felt soil erosion was a "major problem" on their farm, while SCS personnel estimated that it was a problem on 85 percent of the farms. Three years later, after SCS had provided information and assistance, 20 percent of the operators thought they had an erosion problem and SCS estimated that 57 percent of them did.

Recent research has shown that perception of soil erosion is affected by the "proximity effect": that is, farmers and landowners are more likely to identify erosion as a problem somewhere other than on their own farm. Farmers are most likely to identify erosion as a problem in their county, somewhat less likely to identify it as a problem in their own community, and even less likely to identify it as a problem on their own farm. There may be several reasons for this discrepancy. For one, the farmer may not have an erosion problem on his/her own farm. (The research on which the "proximity effect" hypothesis has been based did not involve actual, on-farm evaluations of erosion.) Second, the farmer may not be aware of the magnitude of erosion on the farm because sheet and rill erosion is not characterized by large gullies and dramatic instances of soil loss. Third, the farmer may deny the problem in order to reduce the psychological stress resulting from failure to correct the situation.

Not only do farmers **underestimate** the severity of erosion on their land, they also frequently **overestimate** the extent to which they are practicing good soil conservation. This is especially true in regard to conservation tillage. Researchers have found that farmers consider themselves to be using conservation tillage when they use conservation tillage equipment or reduce the number of passes over the field, even though

residue on the field is far below the standard for conservation tillage.

Institutional Characteristics.--Of all the factors affecting the adoption of conservation practices, institutional characteristics may be among the most influential. Yet they are the least defined, the most difficult to document, and the least researched. The current trend in research, however, is to place more emphasis on these characteristics and less on individual characteristics of farmers and farms. There may be several reasons for this:

o Clear relationships have been found between such characteristics as education, ownership and off-farm employment, and there may be little to be gained by pursuing research in these areas alone.

o The simple relationships between farmer/farm characteristics and adoption explain only a small portion of the variation in conservation behavior, so other factors must be equally, or more, significant.

o The current economic and political climate in which the American farmer functions today is certain to affect conservation decisions, as it affects all other decisions made by the farm unit.

In 1982, social scientists participated in a national RCA Symposium on Future Agricultural Technology and Resource Conservation that was organized to determine the direction that American agriculture is headed, and the effects that modern farming practices have on land use, soil, and the environment. These scientists called attention to the inconsistencies and conflicts between conservation and production goals of USDA agencies, and called for research to evaluate and identify the institutional barriers to conservation. The Food Security Act of 1985 addresses some of these concerns with its "Sodbuster," "Swampbuster," and Conservation Reserve features.

RCA Symposium participants also cited a need to break down barriers among institutions involved in soil and water conservation by decentralizing program control and developing multi-agency planning at the local level. Recent research has shown that, although farmers cite conservation agencies as likely sources of needed conservation information, many are confused about the types of assistance available from individual agencies.

In general, the higher the number of institutional contacts, the greater the likelihood farmers will use conservation practices. Farmers who are district cooperators or who have a conservation plan developed with SCS assistance are more likely to use conservation practices.

Although the influence of institutional factors on adoption of conservation practices remains a relatively unexplored area of research, there is considerable interest in the ways by which innovations and information about them are made available to individuals or households through the activities of organizations (in this case, public agencies). An agency emphasizing this aspect of the adoption process analyzes the characteristics and needs of its clienteles, and then develops strategies to address these characteristics and needs in order to "sell" the agency's programs. This is known as the "market approach" to adoption.

Results from studies of adoption in other sectors suggest that the market approach might achieve greater application of conservation practices. Several recent studies have examined information sources, relationships among conservation agencies and soil and water conservation districts, and characteristics of target clienteles. They have documented the importance of seeing farmers as a "segmented" rather than "mass" audience and of tailoring information and technical assistance to sub-groups based on their common needs, characteristics, stages in decision-making, etc. This approach may be particularly relevant as conservation agencies focus their assistance on areas with the most critical resource problems where it may be necessary to work with a variety of client groups, some of whom may be unfamiliar with agency roles.

Where Do We Go From Here?

Although economic factors are certainly significant in the decision to adopt conservation practices, they fail to account for all adoption behavior. Sociological factors are also significant and, for some farmers and landowners, even outweigh economic considerations. Currently, we know a great deal about the characteristics of farmers and landowners who are most likely to adopt conservation practices. What we do not know very much about is how to motivate farmers who are not likely to use conservation practices without some kind of incentive. Sociological research tells us that this incentive is not always a monetary one.

We need to know more about the values and attitudes of the many different clienteles with whom we work, and the kinds of incentives that will motivate them to use conservation practices. When we have this information, we can develop implementation strategies and marketing techniques that will meet the needs of the target clientele as well as meeting agency goals for the application of soil and water conservation practices.

EROSION IS A PROBLEM ON LAND IN MANY LAND USES

Arkansas. Approximately 5 percent of the state's grassland erodes at rates greater than is tolerable. Additional erosion occurs where mining operations are concentrated.

California. Although over half of the erosion occurs on rangeland, deserts, and wild lands, erosion control is most economically feasible on the state's cropland. Conservation tillage is being practiced on dry cropland, and a combination of cover crops and surface water disposal systems is being used on very steep strawberry-producing, vineyard, and orchard areas.

Georgia. Soil erosion in urban areas, particularly on construction sites, is a serious problem unless adequate erosion control measures are applied. Erosion from unprotected sites is generally many times greater than erosion on agricultural land.

Kentucky. The erosion rate is as high as 72.2 tons per acre per year on lands that have been stripmined or used for farmsteads, quarries, pits, and road construction sites.

Louisiana. Severe coastal marsh erosion is a major resource concern. This delicately balanced marsh system is being converted from vegetated marshes to open water at an alarming rate. This area has the highest resource degradation rate of any area in the nation. Annually 32,000 acres of productive marshlands are eroded away. This amounts to an 88-acre-per-day loss. Coastal marshes provide great benefits to the state and the nation; they support fisheries--including shellfish--as well as migratory and other birds.

Michigan. Wind and water erosion are severe problems on land planted to specialty crops as a result of the cultural methods and lack of adequate crop residue after harvest. For example, the estimated average annual erosion on land planted to asparagus is about 15 tons per acre.

Mississippi. Although cropland erosion is the most severe, conservation treatment is needed on 65 percent of pastureland and 58 percent of forest land.

New York. Up to 90 percent of the soil erosion in urban areas takes place on land under development. Such urban erosion often causes greater economic and environmental damage than erosion in rural areas, because the resulting sediment generally affects waterways and public structures and must be removed.

Ohio. Erosion rates on abandoned strip-mined land often exceed 100 tons per acre per year. More than 65,000 acres need reclamation. Another 3,435 acres of farmland on flood plains has been destroyed by deposition of sediment from the mined land. Flooding has increased in frequency, depth, and extent. Nearly 1,400 miles of streams are contaminated by chemical mine drainage, and 636 miles of waterways contain sediment that is detrimental to crop production.

North Dakota. Most soils in the state can be classified as fragile. These soils have developed under arid or semi-arid conditions that produce topsoils less than 15 inches thick. The productive potential of these soils is rapidly depleted by losses due to wind and water erosion.

Vermont. Forest land erosion, especially on roads leading into woodlands, is excessive. A rising demand for forest products makes the need for improved planning and management more urgent. In addition, more than 600 miles of eroding streambanks pollute waterways with sediment.

LAND USERS AND ALL LEVELS OF GOVERNMENT ARE COOPERATING TO REDUCE EROSION

Alabama. Research is being conducted to determine soil loss and management requirements for minimum tillage systems on erodible lands. Fertility requirements of eroded lands are also being investigated.

Arkansas. USDA provides technical assistance in applying conservation tillage practices to users of highly erodible lands. Field evaluation plantings are being conducted in cooperation with conservation districts to find a suitable winter cover crop for cropland and a grass crop for pastureland.

Colorado. Erosion on farm and ranch land is estimated at more than 200 million tons annually: 112 million from wind, 86 million from water, 18 million from streambank erosion. To combat these losses, several approaches are in use, including a dust-blowing task force drawn from public agencies and private groups, which provides information to state and county decision makers, and a furrow irrigation monitoring program. Plow-out of fragile rangeland (over 670,000 acres in the past 8 years) is coming under regulation in some counties.

Connecticut. The state is experiencing excessive erosion and sedimentation from highway construction and urbanization. Offsite effects include sediment in local streams and along roadways. The state is taking steps to control such situations. Legislation requires sediment control for highway projects receiving federal funds and for development sites.

Illinois. Soil erosion on cropland was the chief concern of the Illinois Water Quality Management Plan, the Illinois Soil Erosion and Sediment Control Guidelines, and the Illinois Resources Conservation Act Report. Nearly a million acres of cropland will need to be converted to alternative land uses, as techniques to protect this land adequately under intensive cultivation are not available.

Kansas. Over half the farmers use conservation tillage, and many citizens participate in the state's 24 active conservation tillage councils. In these councils, farmers, conservationists, bankers, and dealers in farm chemicals and farm machinery work together to solve common problems.

Missouri. From July 1984 to June 1985, Missouri used cost-share funds to install 3,762 conservation practices that saved 5.2 million tons of soil on 62,000 acres. In fiscal year 1985, 2,019 miles of terraces were constructed, an all-time record. Such achievements are increasing because of private and governmental commitment to erosion control.

New Hampshire. Erosion on forest land occurs mainly in association with woods roads and logging operations. About 13,000 acres of roads, trails, and landings need treatment, mostly in steep, mountainous areas. Significant progress is being made in solving these problems. Lake waters, especially in the centrally located Lakes Region, need protection from erosion caused by development activities. A program to inventory watersheds in Belknap and Carroll Counties will provide data for local management.

New Mexico. Both rangeland erosion and cropland erosion are resource concerns. To control rangeland erosion, SCS is assisting land users with grazing management and brush control. Conservation tillage, terrace construction, and conversion of cropland to permanent cover are used to control erosion on cropland.

Oregon. Public information techniques have been extensively and successfully employed in conservation tillage seminars and demonstrations featuring farmers, professional conservationists, and equipment manufacturers. Print and electronic media also have cooperated in telling the conservation tillage story. The success of targeting in the Columbia Plateau region is shown by the dramatic rise in the amount of soil saved (370,000 tons in 1985) and in the number of acres under conservation tillage (from 50,000 in 1981 to 440,000 in 1985).

South Dakota. The Fragile Lands Conversion Pilot Project, conducted by the conservation district in Stanley County and funded by SCS under authority of RCA, has proven to be an effective approach to converting fragile croplands to permanent native grasses. Since 1983, landowners have seeded more than 4,500 acres of highly erodible, thin clay soils to grass. Farmers are paid $20 per year for 3 years and 75 percent of the cost of establishing grass. Landowners in turn agree to maintain the lands in permanent grass for 10 years. The grass, after establishment, can be used for livestock grazing, subject to proper management.

Virginia. For three years, the Piedmont Bright Leaf Erosion Control Project has surpassed its annual goal for protecting cropland from erosion. Acreage of protected cropland has risen from 10,585 before targeting to 29,740 in 1985. Other areas also have been targeted for special projects to reduce cropland and pastureland erosion.

West Virginia. Pastureland acreage far exceeds cropland in the state, so erosion control efforts have been directed mainly at pasture management. In addition to conducting a strong statewide information campaign, SCS has established the eight-county Potomac Headwaters Target Area in the eastern part of the state. Erosion reduction in 1985 in the target area was more than double the goal.

Wisconsin. An aggressive state program to protect farmland from erosion is summarized in the slogan "T by 2000" for every county in the state. In addition, legislation mandates that conservation measures be in place before a farmer can receive tax advantages.

Wyoming. A recently-completed critical erosion map for cropland is being used to develop resource management systems for those cropland areas that need erosion control.

CHAPTER 4
Salts and Sodium Affect Some Soils

If the soil moisture around plant roots contains too much salt, most crops cannot absorb the water and nutrients they need to germinate and grow well. Saline or sodic (excessive sodium) conditions are lowering productivity on about 9 percent of the nation's cropland and pastureland, including more than one-fifth of the irrigated cropland and pastureland.

Salt accumulation is a problem mainly in arid and semiarid regions where precipitation is insufficient to leach salts from the soils. Seven water resources regions west of the Mississippi have manifest salinity or sodicity problems on 5 to 30 percent of their cropland and pastureland.

Irrigating with saline water or poor management of irrigation water can cause salinization of insufficiently drained, irrigated land. Efforts to deal with salinization must be carefully planned to ensure that the problem is reduced, not just moved to another area. If return flow from irrigation carries excessive amounts of salt, the water may cause crop losses downstream, may be rendered unfit for people and animals to drink, and may cause high mortality of fish and other stream organisms.

Some dryland cropping practices--such as the alternate crop-fallow system--and land uses can cause saline seeps to form. Saline seeps occur where salt-bearing ground water emerges or accumulates near the surface, downslope from recharge areas where precipitation enters the soil.

Saline soils and seeps have an excess of soluble salts in the root zone, which causes plant yields to decrease (fig. 30). Severe salinity may completely prevent crop growth. Sodic soils contain excessive amounts of adsorbed sodium. Sodium saturation causes poor soil structure and severely limits water infiltration unless the soil is also saline. For the defining criteria used in this report for saline, slightly saline, and sodic soils, and for the acreage of such soils by state, see tables 30 and 31 in Appendix C and their explanatory notes (pages 248-251).

In humid areas, rainfall long ago flushed much of the soluble salts from the soils. In areas with limited rainfall, the salts have not been leached away. When land in these areas is irrigated, leaching becomes intensive. Well drained soils on higher parts of the landscape gradually become less saline when irrigated with good quality water, because irrigation water dissolves salts and transports them into ground water, which may return to feed into surface supplies. This process adds salts to waters downstream. When these more saline waters are used for irrigation downstream, salts accumulate in low-lying, poorly drained areas.

Trace metals are more soluble and mobile in saline water than in nonsaline water. Thus they tend to accumulate along with the common soil salts.

Saline seeps typically have a white salt surface crust. They occur where salt-bearing ground water, flowing over an impervious layer, emerges on the surface of a slope or accumulates near the soil surface wherever the flow is obstructed. On nonirrigated croplands in arid and semiarid areas, especially those of the High Plains, saline seeps (fig. 31) are developing where crop-fallow rotations are using less water than was used by the natural vegetation. The unused soil water carries salts along as it percolates downward. Where its movement is slowed or confined, the water table rises toward the surface and salts and soil wetness build up.

Figure 30.--The white crust of accumulated salts indicates the cause of heavy crop losses in an irrigated field of cotton in California. Cotton is considered salt-tolerant (table 10).

Figure 31.--This saline seep in north-central Montana has grown to cover nearly 60 acres.

What kinds of damage result from salinity and sodicity?

Where soil has become saline, farm and ranch operators generally experience reduced yields and a reduction in net income. They may have to change their crop mix to more salt-tolerant crops.

Some plants are highly sensitive to salt while others are quite tolerant. Table 10 shows the approximate reductions in yield that specific levels of salinity can be expected to induce in certain plants. The figures are based on average conditions in arid and semiarid regions where surface irrigation methods are used; a plant's tolerance may differ in a more humid environment or under sprinkler irrigation. 1/

Irrigation water contains dissolved salts, which become more concentrated in the soil solution as water is consumed by crops or lost by evaporation. Therefore, additional irrigation water must be applied periodically to leach the excess salts from the root zone. Subsurface return flows from irrigation may also dissolve and transport more salts from the subsoil and underlying layers. Because return flows from irrigation are more saline than the applied water, downstream irrigators may need even more water to wash the salts out of their soils. (See pages 110-111 for more on salinity and irrigation.)

In addition to ruining thousands of acres of productive farmlands, water flowing from saline seeps has been observed to cause scours, staggers, and occasionally blindness and death in livestock. Water from seeps commonly contains much higher concentrations of nitrates and trace elements than are found in water samples from nearby areas.

The inflow of saline waters or of waters containing high concentrations of toxic elements (such as boron, selenium, and cadmium) can damage or destroy habitat for fish and wildlife, especially in wetlands. (See Wildlife Habitat, page 123 ff., and Wetlands, page 133 ff.)

Salinity or a high concentration of sodium can make water unfit for human consumption. Deterioration of ground water may go undetected for a long time and cannot be readily reversed. (See page 112.)

Table 10.--Salt tolerance of selected crops

Crop	Salinity 1/ at the point where yield begins to decline	Yield decrease 2/ for each added unit increase in salinity	Salt tolerance rating 3/
Alfalfa	2.0	7.3	MS
Apricot	1.6	24.0	S
Barley (forage)	6.0	7.1	MT
Barley (grain)	8.0	5.0	T
Bermudagrass	6.9	6.4	T
Cabbage	1.8	9.7	MS
Clover	1.5	12.0	MS
Corn (forage)	1.8	7.4	MS
Corn (grain)	1.7	12.0	MS
Cotton	7.7	5.2	T
Grapefruit	1.8	16.0	S
Lettuce	1.3	13.0	MS
Onion	1.2	16.0	S
Orchardgrass	1.5	6.2	MS
Potato	1.7	12.0	MS
Rice	3.0	12.0	MS
Soybean	5.0	20.0	MT
Sugar beet	7.0	5.9	T
Tomato	2.5	9.9	MS
Wheat	6.0	7.1	MT
Wheatgrass, tall	7.5	4.2	T

1/ Salinity is expressed as electrical conductivity of the water in the soil in millimhos per centimeter at 25° C.
2/ Yield decreases are given as percentages of unaffected yields at sites where climate and soils are similar.
3/ S = sensitive; T = tolerant; MT = moderately tolerant; MS = moderately sensitive. Ratings for some tree crops are based on growth rates rather than yield responses because of limited data.
Source: Maas, E.V. and G.J. Hoffman, June 1977. Crop salt tolerance--current assessment. Journal of the Irrigation and Drainage Division, ASCE, Vol. 103, No. IR2, Proc. Paper 12993.

1/ For a detailed explanation of the relationship of salinity to plant physiology, see Salt water intrusion of ground water in the contiguous United States, Vol. III, Part A, chapter II. Environmental and Ground Water Institute, University of Oklahoma, 1985.

Land affected by salinity: More extensive than we thought

In the 48 conterminous states, more than 48 million acres of cropland and pastureland are either sodic or affected by varying degrees of salinity (table 11). This estimate was obtained by cross-referencing information collected by the National Cooperative Soil Survey and the 1982 National Resources Inventory (NRI). The acreage thus derived is larger than that reported in the NRI or any earlier inventory. Data collected by sample inventories alone, without reference to soil laboratory data, apparently recorded as sodic or salt-affected only those soils that are severely affected. Experiments have demonstrated that yields of some plants are reduced in soils that are only slightly affected.

Soil salinity occurs mostly in the arid and semiarid areas of the West. Six of the western water resources regions have salinity problems on about one-third or more of their cropland and pastureland (fig. 32).

Nearly 14 million acres of irrigated cropland and pastureland in the continental United States are affected by salinity or sodicity. In 9 of the 12 western water resources regions, the percentage of affected cropland and pastureland is higher for irrigated land than for nonirrigated land (tables 11 and 12; see also fig. 33). Inefficient irrigation practices in either upstream or downstream areas can accelerate the rate of salinization. Acreages of salt-affected areas tend to increase as long as salt-bearing waters are applied without adequate drainage. Notable among locations where salinity is increasing because of irrigation practices are areas in southern California, parts of the lower Gila River basin in Arizona, and parts of the Rio Grande basin in southern New Mexico and western Texas. As consumptive uses of water increase in the future, salinity downstream will tend to increase.

In the Upper Mississippi, Souris-Red-Rainy, and Missouri regions, a higher percentage of nonirrigated land than irrigated land is affected. Salinity in nonirrigated land increases as a result of saline seeps. In 1981, a report 1/ on the saline seep problem in six Great Plains states estimated their saline seep

1/ Unpublished report by the Program Integration Staff, Planning and Evaluation, Soil Conservation Service.

Table 11.--Cropland and pastureland affected by salinity and sodicity, by region

Water resources region	Saline 1/	Slightly saline 1/	Sodic 1/	Total affected	Total cropland/ pasture	Percent affected
	---------------------------(1,000 acres)-----------------------					
New England	0.0	0.0	0.0	0.0	3,116.8	0.0
Mid-Atlantic	0.0	0.0	0.0	0.0	18,852.2	0.0
South Atlantic-Gulf	21.3	12.2	3.9	37.4	42,728.8	0.1
Great Lakes	0.0	0.0	0.0	0.0	28,181.3	0.0
Ohio	0.0	0.0	32.5	32.5	48,752.5	0.1
Tennessee	0.0	0.0	0.0	0.0	8,291.6	0.0
Upper Mississippi	15.2	1,177.7	238.1	1,431.0	80,075.5	1.8
Lower Mississippi	40.8	52.9	632.7	726.4	28,467.4	2.6
Souris-Red-Rainy	621.5	6,547.3	528.5	7,697.3	22,532.5	34.2
Missouri	3,599.7	15,075.6	2,775.0	21,450.3	125,428.5	17.1
Arkansas-White-Red	167.0	1,174.7	565.5	1,907.2	60,539.7	3.2
Texas-Gulf	1,097.1	2,231.7	159.2	3,488.0	39,199.6	8.9
Rio Grande	527.3	1,260.4	103.1	1,890.8	2,593.7	72.9
Upper Colorado	411.0	320.5	31.7	763.2	2,344.8	32.5
Lower Colorado	195.5	795.5	23.3	1,014.3	1,574.7	64.4
Great Basin	952.3	748.1	152.3	1,852.7	3,728.9	49.7
Pacific Northwest	849.1	1,271.4	128.1	2,248.6	23,430.8	9.6
California	1,944.4	1,108.3	859.9	3,912.6	12,203.3	32.1
Hawaii	0.0	0.0	0.0	0.0	1,307.2	0.0
Caribbean	15.8	0.0	0.0	15.8	1,363.3	1.2
TOTAL	10,458.0	31,776.3	6,233.3	48,468.1	554,713.1	8.9

1/ For more data and for definitions of these terms, see Appendix C, table 30.

Sources: USDA-SCS, 1982 National Resources Inventory.
National Cooperative Soil Survey.

acreage at a total of 536,600 acres, including 143,600 in North and South Dakota and 200,000 in Montana. A more recent (1987) estimate by the Montana Salinity Control Commission set Montana's saline seep areas at 300,000 acres. The 1981 estimate may be low because slightly and moderately saline soils often cannot be detected visually.

It is not uncommon for seep areas to expand by 20 to 200 percent in wet years, but in dry years expansion may be very slight or may even be reversed. The growth of saline seeps in one small watershed was traced in aerial photographs taken 5 to 10 years apart between 1941 and 1971 (during which time no measures were taken to control the problem). 2/ For most of that period, seep expansion averaged about 15 percent per year, but from 1951 to 1956 the average annual increase was more than 40 percent.

2/ Bahls and Miller, cited in Brown et al., 1982.

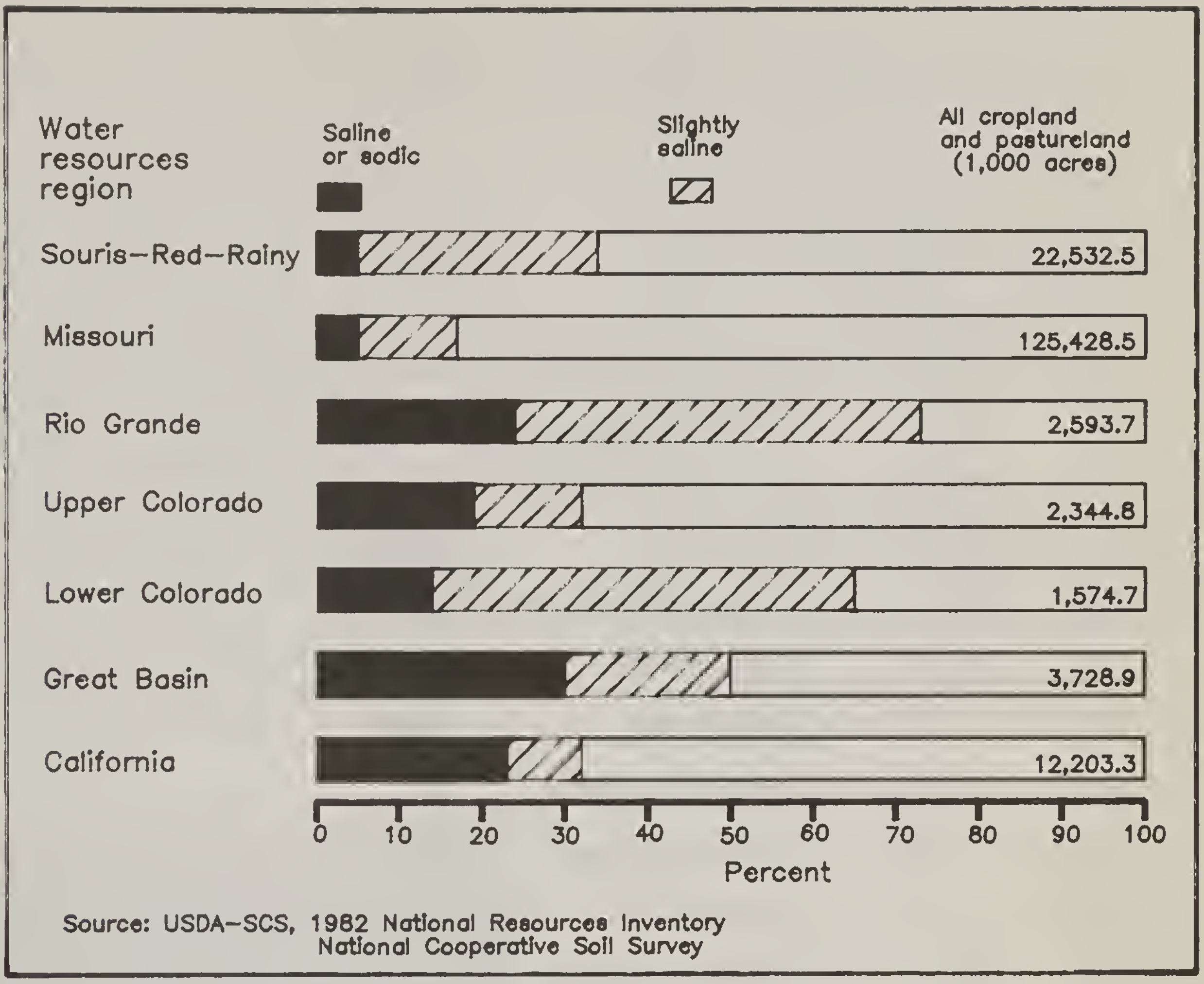


Figure 32.--Affected portion of all cropland and pastureland in seven western regions.

Table 12.--Salinity and irrigation, in selected regions

Water resources region	Irrigated cropland and pastureland: Total acreage	Irrigated cropland and pastureland: Saline, slightly saline, or sodic 1/	Affected portion of irrigated soils	Irrigated portion of total affected cropland and pastureland
	(1,000 acres)		(percent)	
Upper Mississippi	921.9	3.6	0.4	0.3
Lower Mississippi	5,210.4	440.8	8.5	60.7
Souris-Red-Rainy	96.5	23.6	24.5	0.3
Missouri	13,928.8	2,068.3	14.8	9.6
Arkansas-White-Red	7,508.5	372.4	5.0	19.5
Texas-Gulf	6,958.7	1,042.5	15.0	29.9
Rio Grande	1,932.5	1,459.8	75.5	77.2
Upper Colorado	1,608.2	665.2	41.3	87.2
Lower Colorado	1,521.5	1,005.1	66.1	99.1
Great Basin	2,462.7	1,434.6	58.3	77.4
Pacific Northwest	8,427.2	1,842.6	21.9	81.9
California	9,997.5	3,546.6	35.4	90.6

1/ For more data and for definitions of these terms, see Appendix C, table 31.

Sources: USDA-SCS, 1982 National Resources Inventory.
National Cooperative Soil Survey.

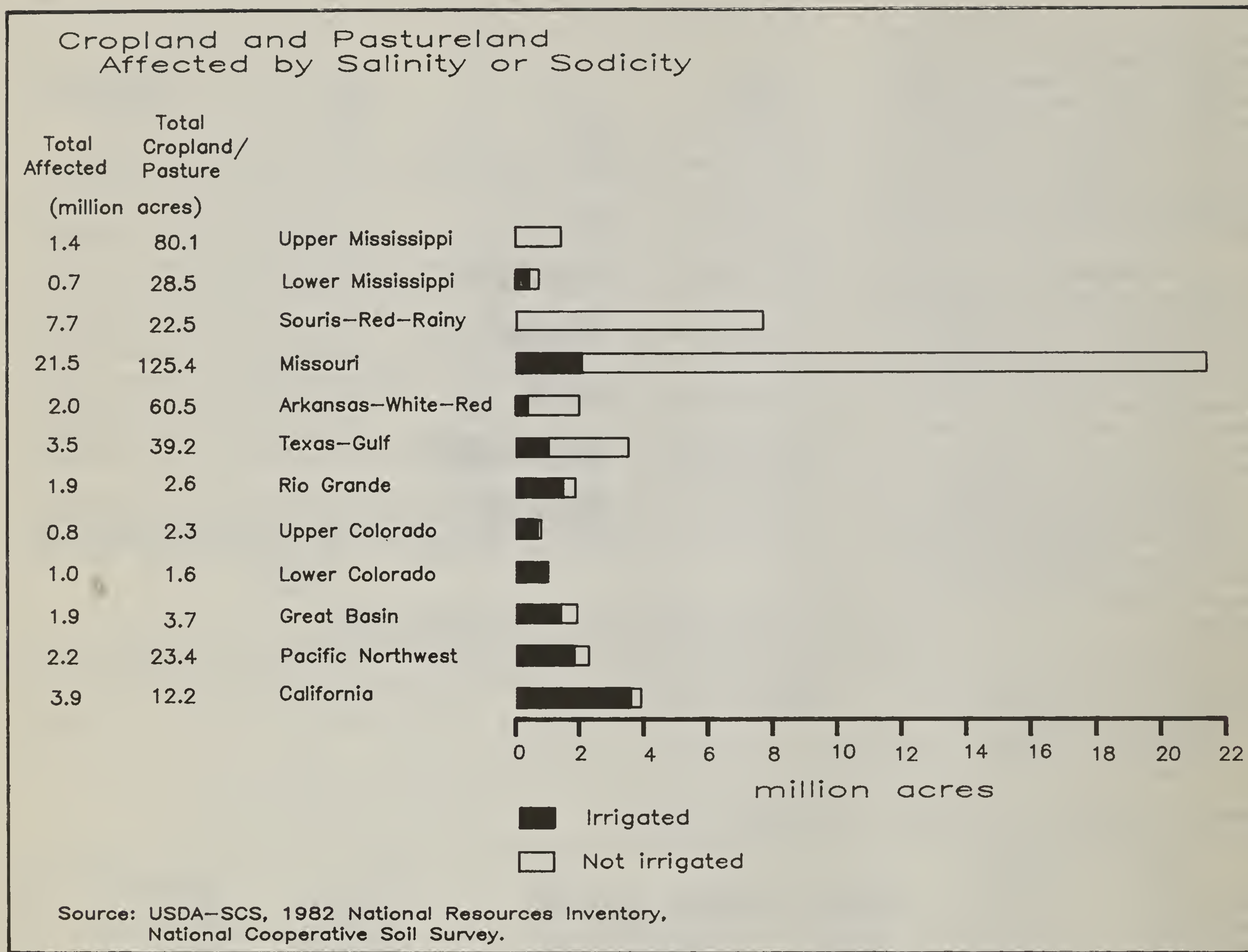


Figure 33.--Acreage of irrigated and nonirrigated cropland and pastureland affected by salinity or sodicity in the 12 western water resources regions.

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What is being done to reduce salinity problems?

In areas where salinity is related to irrigation and drainage, the Department of Agriculture is providing technical assistance to landowners who want to improve irrigation water management and provide adequate drainage. Drainage assistance is provided only where it involves no reduction in or damage to wetlands and has no impact on downstream water quality.

In the Colorado River Basin, USDA's Soil Conservation Service and Agricultural Stabilization and Conservation Service are cooperating with the Bureau of Reclamation, state government agencies, conservation districts, local government agencies, and landowners to promote practices that reduce the flow of salts into downstream waters.

In dryland saline seep areas, reclamation strategies center on increasing the water uptake by crops in the upslope recharge area. Recharge area treatments include planting deep-rooted crops, such as alfalfa, and intensifying crop rotations to reduce the acreage and frequency of summer fallow. Farmers can improve management of soil moisture conditions through crop rotations, annual cropping, and surface drainage. Reclamation can occur within 5 years with intensive cropping (including alfalfa) in the recharge area. Reclamation is not permanent unless the recharge area is carefully cropped to use precipitation and prevent ground water buildup. Water table monitoring is crucial in evaluating the success of reclamation measures, because the water table level in the discharge area is related to the salinity hazard. If the water table can be kept below a 6-foot depth, the salinity hazard generally can be eliminated as precipitation leaches the salt away.

USDA also is conducting research in the use of alternative crops (such as salt-tolerant vegetation) for treating seep discharge areas and adaptive oilseed crops and legumes in the recharge areas and in methods for detecting and managing salinity problems.

Salt damage to irrigated corn in western Colorado.

YIELDS ARE AFFECTED BY SALINE OR SODIC CONDITIONS

California. Salinity was identified as the state's most serious resource problem in "California's Soil Conservation Report," prepared for the Secretary of the State Resources Agency. About half of the state's nearly 10 million acres of irrigated cropland is affected by salinity or sodicity. About 2.9 million acres are naturally saline or sodic soils, and 1.6 million acres have become saline as a result of application of saline irrigation water. SCS expects this acreage to exceed 5 million acres by the year 2000, unless significant improvements in the treatment of the problem are achieved. Five of the nation's top 10 agricultural counties are seriously affected in the San Joaquin Valley. Salinity accounts for a significant decrease in agricultural productivity. A 1-percent decrease in the productivity of irrigated cropland in California equals about $80 million annually.

Montana. Special multi-county saline seep conservation districts have been formed. The first such district hired a team to identify saline seep areas and develop treatment plans. That team now works with a statewide program and is funded through State government, local conservation districts, and landowners. Using ARS research, conservation districts and SCS are developing treatment plans that use perennial vegetation to dry out the soil profile and flexible cropping systems which efficiently utilize soil moisture and allow surface salts to be leached into the soil profile below the root zone. SCS is conducting a saline seep inventory and is cooperating with Montana State University in a research project to use remote sensing to inventory and monitor areas affected by saline seep. Two projects demonstrating saline seep reclamation techniques were funded with RCA grants.

Nevada. Salt in the root zone of soils is a problem on more than 20,000 acres of irrigated land. Irrigation water exceeding the amount required to meet consumptive use must be applied to leach the salts, which end up in streams and lakes, impairing water quality. Damaged areas include the Colorado River, wetland areas around Fallon and Yerington, and several irrigated areas. Some monitoring of water tables and salt concentrations has been done to determine the extent of the problem; observation wells have been installed to determine changes in water table levels. These data are correlated with the associated effects on crop yields and with farmers are handling the problem.

Oklahoma. Saline and sodic soil conditions are reducing crop yields and increasing susceptibility to soil erosion on more than 500,000 acres of formerly productive cropland, mainly in western and northwestern regions. Because of adverse effects of salt concentrations or sodium at or near the surface, most affected areas do not support adequate plant growth or produce enough crop residues to protect the soil from severe wind and water erosion. The size of saline seep affected areas is expanding rapidly.

CHAPTER 5
Rangeland Resources Need Protection

Range vegetation is an important renewable resource that is an integral part of the resource base. The major rangeland resource is vegetation--principally grasses and grasslike plants, forbs, and shrubs. Many factors influence that vegetation, especially soil, climate, topography, fire, drought, and animal life. Soil, plants and indigenous animals develop concurrently. At first only annual, ephemeral, pioneer plants and primitive animal life are able to subsist on a site, but they make their organic contribution to soil development. Eventually, through a series of successional changes, a diverse and stable plant community evolves, self perpetuating and in dynamic equilibrium with the soil and other elements of the habitat. This climax vegetation, the product of the total environment, is the best suited to the soil, moisture, temperature, and other environmental conditions of that site. It is the most stable and generally the most productive natural plant community the site is capable of supporting. If the climax vegetation is destroyed, restoration is painfully slow. If the site is allowed to deteriorate, for example through soil erosion, restoration may be impossible.

The health of rangeland is measured by range condition. Much of our rangeland was severely damaged during the 19th century because policy makers and settlers were unfamiliar with the fragility of range ecosystems. Range scientists report that rangeland has generally been improving in condition since the 1930's. In spite of that trend, 61 percent of nonfederal rangeland remains in less than good condition. As a result, erosion and deterioration in the quality of plants continue in some areas.

Continued good management to maintain the improvement achieved so far is important because it is more costly to restore productivity and profitability than it is to maintain rangeland in good or excellent condition. Good management of rangeland increases forage for livestock, improves habitat for wildlife, and can increase the quality and quantity of the water supply that originates in rangeland watersheds.

This chapter presents data on the 406 million acres of nonfederal rangeland included in the 1982 National Resources Inventory. Data on federal rangelands are collected by the USDA Forest Service as part of the periodic assessment required by the Renewable Resources Planning Act of 1974 (RPA). There are 329 million acres of federal rangeland including rangeland in Alaska. The U.S. Department of the Interior, Bureau of Land Management, administers almost two-thirds of federal rangeland.

Range Condition and Trend: Where Is Action Needed?

The health of rangeland and the degree to which it will respond to improved management are judged by comparing the present vegetation of a site to the climax vegetation. The degree to which the kinds and proportions of plants in the existing plant community resemble those of the presumed climax vegetation for the site is called range condition. USDA's Soil Conservation Service and USDI's Bureau of Land Management define four range condition classes: excellent, good, fair, and poor. Range condition ratings are not assigned to areas dominated by introduced species.

Range condition on nonfederal rangeland varies considerably by state (fig. 34). At the national level, range condition appears to be similar on nonfederal rangeland, state-owned rangeland, and the federal rangeland administered by the Bureau of Land Management. About 61 percent of all nonfederal rangeland and 65 percent of state-owned rangeland are in poor or fair condition and, therefore, need improvement. Available data indicate that 60 percent of the rangeland administered by the BLM are in poor or fair condition. The five percent of federal rangelands that are administered by the USDA Forest Service cannot be compared to nonfederal or BLM-administered lands because the Forest Service uses a system that defines five condition classes.

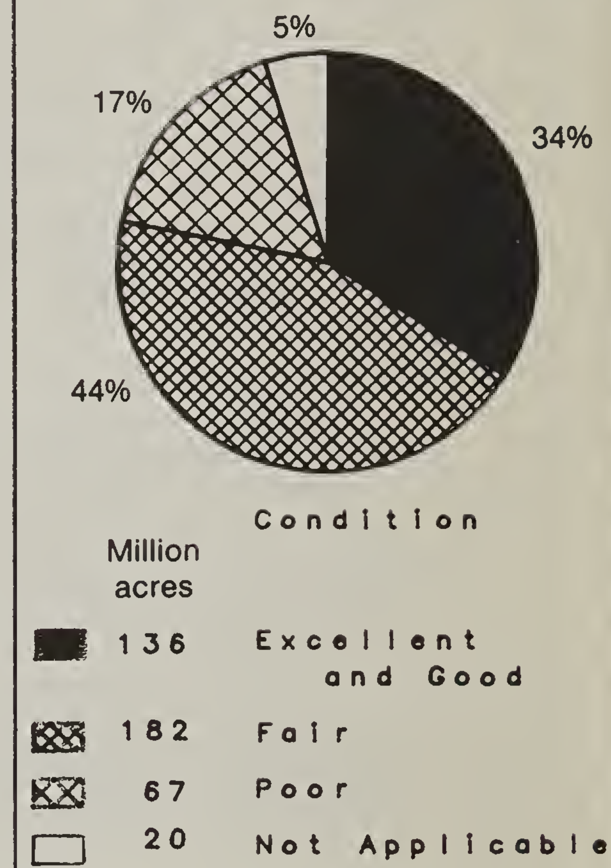
Generally, the correlation between range condition and the quality of the range is high. As a rule, a site in good or excellent condition produces more forage and provides better habitat for native animals. Water infiltration is higher and runoff and erosion are lower. However, range condition indicates only the degree to which existing vegetation differs from the climax community. It is not a rating of the value of the vegetation for any specific use. Any of a number of causes may induce a departure from the climax community, and the resulting vegetation may be more or less valuable for a particular use than the species in the climax community.

Trend in range condition is the direction a plant community is changing in relation to the climax vegetation for the site. Because the fragile soils and harsh climate make proper range use essential, trend is the most important part of the range resource inventory. All conservation and management actions are based on whether or not the range is improving, deteriorating, or maintaining its current status.

Range management scientists generally believe that range condition reached a low point in the 1930's and has been slowly improving since that time. SCS conducted rangeland assessments in 1963, 1977, and 1982. Although methods differed considerably in the three assessments, they do indicate that range condition has improved since 1963. There is little difference in the condition of rangeland reported in the 1977 and 1982 NRI. This is not cause for concern in itself, because range condition generally improves slowly. In the 1982 NRI, rangeland trends were documented as not changing on 69 percent of the land and changing on 31 percent of the land. The trend was up on 16 percent of the rangeland and down on 15 percent.

Over the past decades, range condition has improved because ranchers have worked to correct the problems. Government programs have provided technical and financial assistance. Available data suggest, however, that measures to improve the most severely damaged rangeland have been applied less intensively in the past few years. There are several reasons for this: the cost of most brush control methods has increased; constraints have been placed on use of herbicides to control brush; economic conditions have reduced livestock producers' investment capital; and federal programs have reduced assistance available for range management.

United States



Range condition rating indicates the degree to which the kinds and proportions of plants in the existing plant community resemble those of the presumed climax vegetation for the site.

Condition class	Percent of existing plant community that is climax
Excellent	More than 75 percent
Good	51 to 75 percent
Fair	26 to 50 percent
Poor	less than 25 percent

Not applicable means that the site is dominantly introduced species.

Source: USDA-SCS, 1982 National Resources Inventory

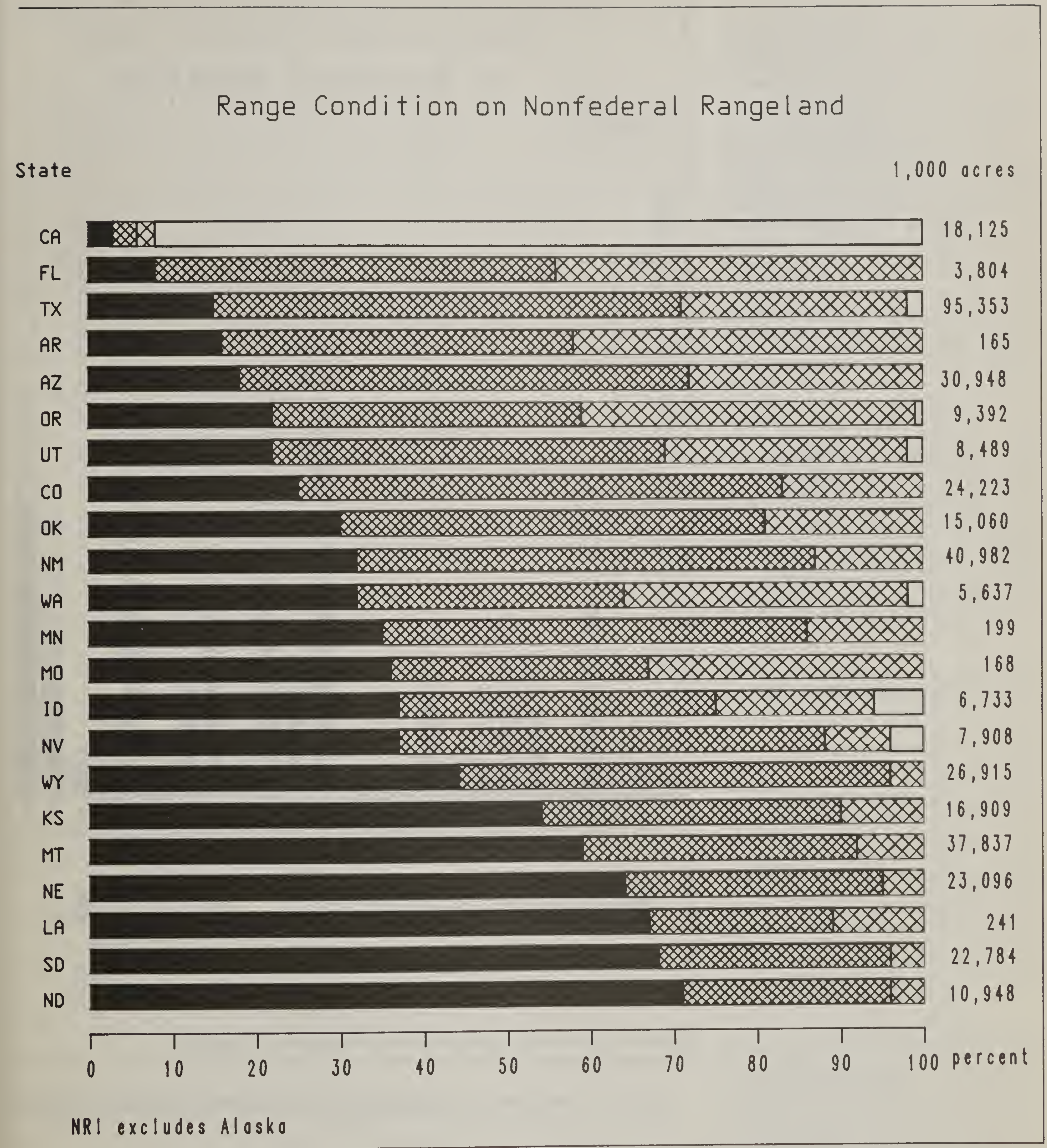


Figure 34.--Range condition on nonfederal rangeland. For additional data see appendix table 32.

Protecting and Enhancing Rangeland Resources: What Can Be Done?

Rangelands are natural ecosystems and are managed by varying the frequency and intensity of grazing and the season of use. Rangeland is not cultivated and, with few exceptions, is not routinely fertilized, overseeded, drained, irrigated, or mechanically harvested. Only on severely depleted rangeland do managers resort to drastic reclamation measures such as brush management, mechanical soil treatment, range seeding, and erosion control practices.

On rangeland, there is generally little or no distinction between "production" practices and "conservation" practices because the actions that increase forage production also protect the soil and conserve water.

Some rangeland is well managed. About one-third of nonfederal rangeland (136 million acres) was identified in the 1982 NRI as adequately protected and thus needs only continued proper management (fig. 35). In this category are those acres where range condition, soil erosion, and other factors that influence sustained productive use of the resource are within acceptable limits.

Improved grazing management would improve conditions on some rangeland. About one-third (134 million acres) of nonfederal rangeland needs improvement that can be achieved through refinements in grazing management. On rangeland that can be adequately improved and protected by better management, the desired vegetation is present, but the vigor or stand needs improving. The improvement can be accomplished by practices such as proper grazing use, deferred grazing, planned grazing systems, and fencing and water facilities for improved animal control and grazing distribution.

More intensive measures would be required to improve conditions of some rangeland. Protecting and enhancing most of the remaining one-third (117 million acres) would require more intensive treatment, such as brush management, range seeding, or erosion control. (Treatment is not feasible on 19 million acres.)

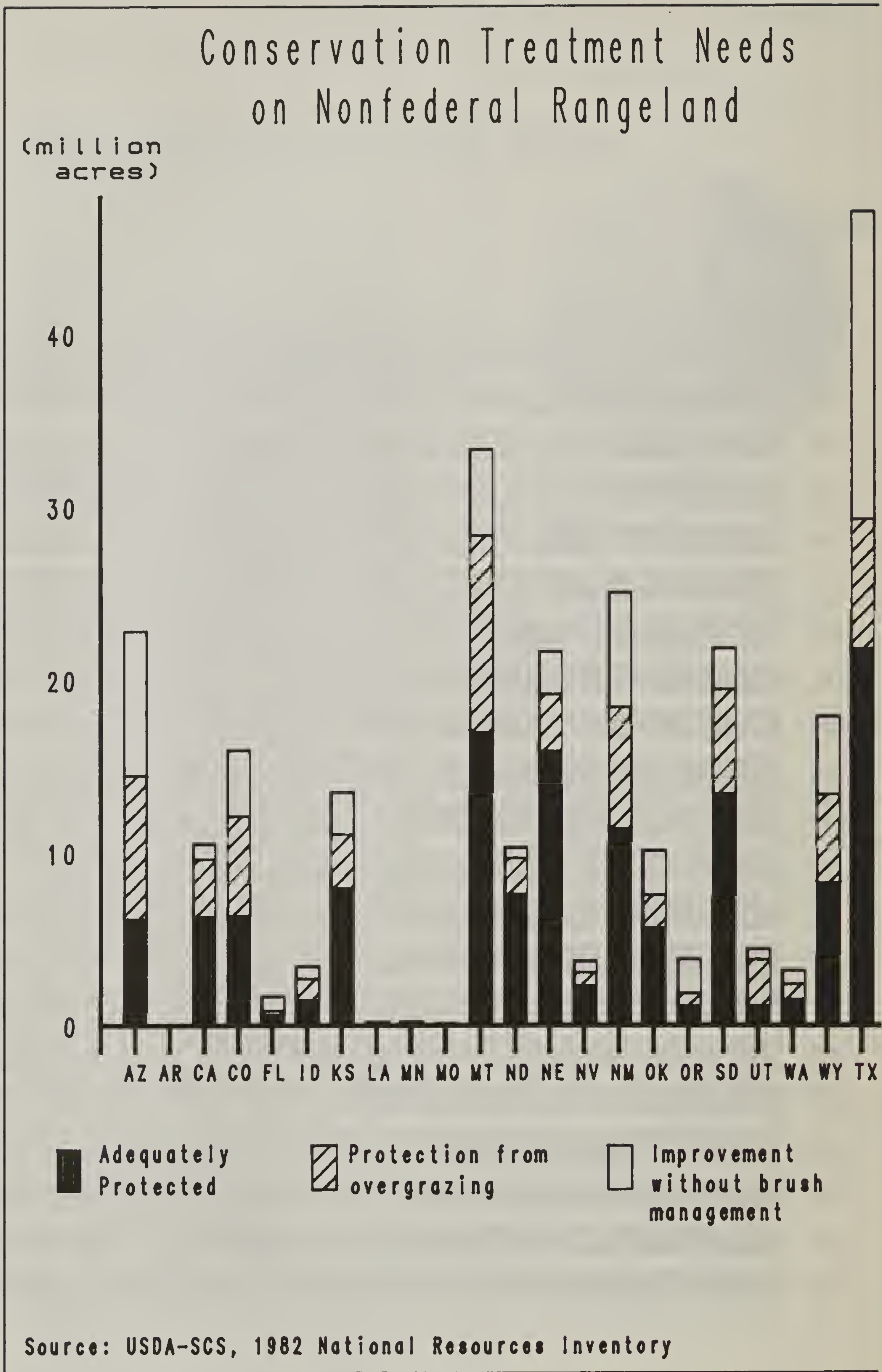
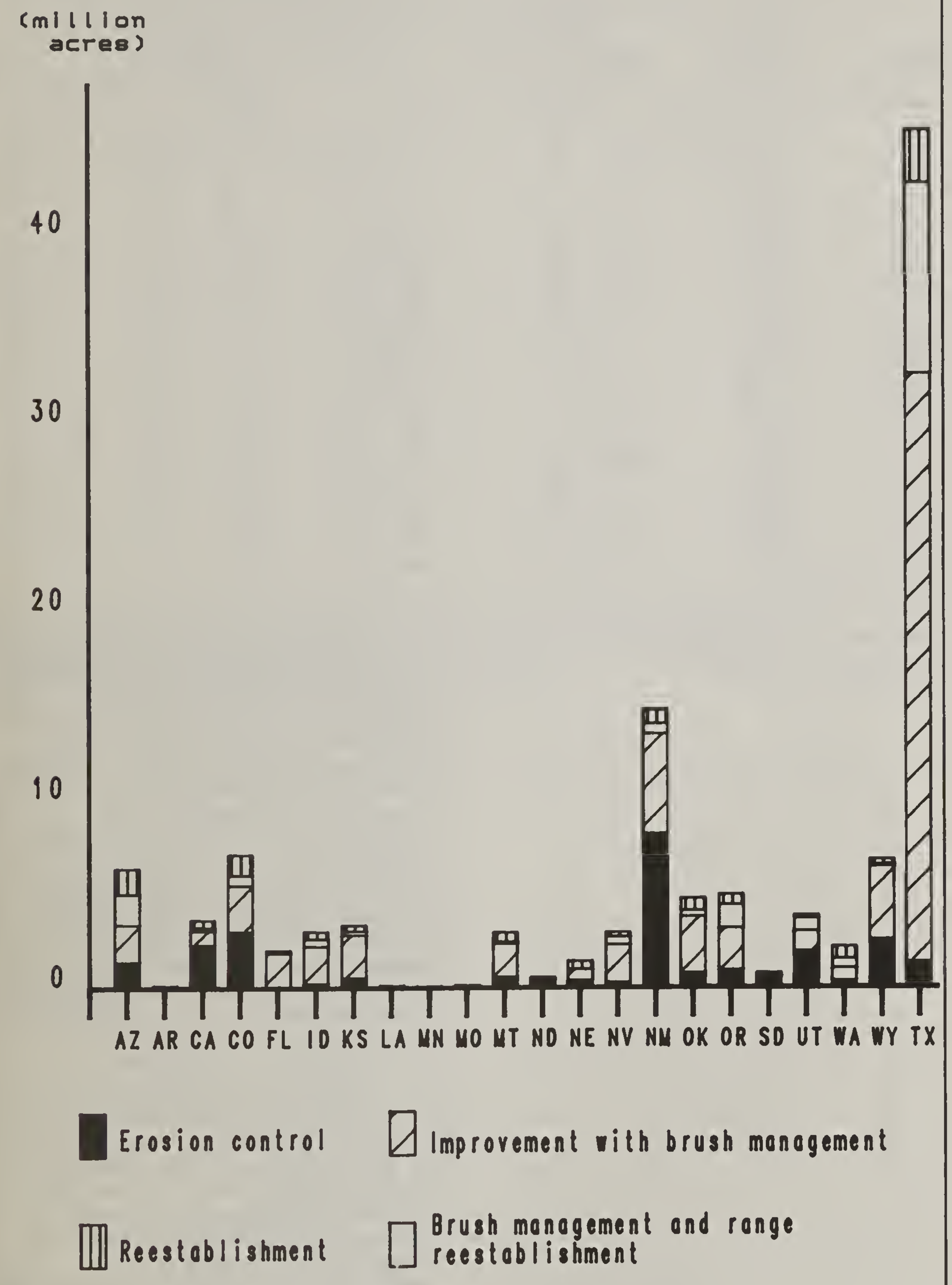


Figure 35.--Conservation treatment needs on nonfederal rangeland, 1982.



For additional data by state, see appendix tables 33 and 34.

Brush management.--Invasion of brush is directly related to both deterioration of the plant community and soil erosion. Brush, as defined here, includes perennial woody plants that have encroached upon areas where they are not part of the climax plant community or that have thickened in density on sites where only small amounts were natural. Major problem plants include mesquite, juniper, sagebrush, several species of oak, sawpalmetto, creosote bush, chaparral shrubs, and cactus.

Brush reduces production of desirable forage species, adversely alters the hydrology of the site, interferes with the handling of livestock, and renders the site more susceptible to erosion. For example, on many sites where junipers have encroached, soil erosion is severe between shrubs and cannot be arrested through management or exclusion of livestock alone. Degradation of the soil and plant community is inevitable and irreversible until the juniper trees are controlled. Moisture use by deep-rooted brush species has caused springs to cease flowing and reduced formerly permanent streams to intermittent draws. Brush management methods include the use of herbicides, mechanical and biological measures, and controlled burning.

In 1982, about 36 percent of all nonfederal rangeland had a woody canopy cover of more than 10 percent, and 16 percent had more than 25 percent cover (fig. 36). Brush management is the main conservation treatment that can benefit almost 81 million acres of rangeland. The vegetation on over 17 million acres of rangeland is so degraded that brush control must be accompanied by reestablishment of desirable forage plants. The need for brush management on rangeland is most severe in the southwest.

Reestablishment of vegetation.--Over 28 million acres (7 percent) of nonfederal rangeland need range seeding to reestablish desirable vegetation. This acreage includes both abandoned cropland and severely depleted rangelands that cannot be expected to recover productive capacity in a reasonable time through management alone.

Almost 11 million acres need seeding only; another 17 million need both seeding and brush control.

Erosion control.--Properly managing the vegetation is the first line of defense against erosion on rangeland. On range in good or excellent condition, a vigorous stand of adapted native vegetation provides effective protection against severe winds and occasional torrential rainstorms. Erosion does not become visible on rangeland until the vegetation has been severely damaged, exposing bare soil.

Improving range condition reduces erosion. Table 13 shows the erosion reduction that could be achieved if all nonfederal rangeland were improved to good condition in several areas where livestock grazing is concentrated. Twenty-eight percent of total sheet and rill and wind erosion in these areas could be eliminated by improving range condition. Potential improvement was estimated using the universal soil loss equation (USLE) and the wind erosion equation (WEQ). The reduction shown in the table is a conservative estimate of what could occur in reality.

Table 14 summarizes the erosion reduction that could be achieved by applying the specific practices needed to improve range condition in 18 selected major land resource areas. The percentages of erosion reduction shown in the table apply only to the acres needing the specific treatment and not to the entire area. For example, in major land resource area 78 (Central Rolling Red Plains), on the acres where the primary conservation need is erosion control, nearly 70 percent of the erosion could be prevented by applying erosion control measures. On the acres where the vegetation could be improved to satisfactory condition by improved management alone, applying grazing management would reduce the erosion by 65 percent. Applying brush management or vegetation reestablishment to the lands where those practices are the primary needs would reduce erosion on those acres by 71 percent and 80 percent respectively.

Table 13.--Estimated average annual erosion on nonfederal rangeland, selected major land resource areas (MLRA)

MLRA	Sheet and rill	Wind
	(million tons)	
8	4.2	4
9	1.7	--
25	2.3	.5
28A	8.2	26.3
41	4.3	5.4
54	7.3	.1
58A	15.7	--
58B	20.7	--
63A	7.3	--
65	8.8	11.2
67	12.	4.
70	24.	30.9
76	4.9	--
78	40.4	11.7
81	33.9	2.7
85	10.	--

Source: 1982 National Resources Inventory.

Table 14.--Estimated percentage of erosion reduction achievable by improving all nonfederal rangeland in poor and fair condition to good condition, selected major land resource areas (MLRA)

MLRA	Sheet and rill 1/	Wind 2/
8	9	65
9	20	--
25	18	20
28A	34	55
41	13	97
54	14	2
58A	7	--
58B	7	--
63A	15	--
65	16	62
67	18	82
70	12	68
76	36	--
78	34	24
81	53	16
85	53	--

1/ For sheet and rill erosion, it is assumed that if rangeland in fair condition were improved to good condition, the cover value (C factor of the USLE) would equal that of rangeland in good condition at that range site and major land resource area. If the C factor recorded for good condition rangeland was lower than that for land in fair condition, the higher C value was used for the calculations because it is assumed that improving condition would not reduce the cover value.

2/ For wind erosion, it is assumed that improving the range condition class would result in the same rate of wind erosion as that estimated for rangeland in the higher class in the area. Where erosion was not inversely related to condition class, however, it is assumed that improving the condition would not result in more erosion but rather that the rate of erosion would remain unchanged.

3/ Dashes indicate that a particular form of erosion is not a problem.

Source: 1982 National Resources Inventory.

Table 15.--Estimated percentage of erosion reduction achievable by applying primary conservation treatment needs on nonfederal rangeland, selected major land resource areas (MLRA).

MLRA	Primary conservation treatment need: Grazing management	Brush management	Vegetation reestablishment	Erosion control
8	73	74	83	89
9	68	0	56	58
23	40	46	56	50
25	15	17	58	87
28A	45	17	27	24
41	71	91	73	58
54	62	39	69	63
58A	70	50	90	78
58B	30	30	0	50
63A	68	68	90	61
65	73	90	94	85
67	39	60	93	55
70	53	71	83	71
76	50	54	81	47
78	64	71	80	70
81	70	74	81	81
85	75	79	83	77
155	0	8	58	84

The percent of erosion reduction indicated for each practice applies only to the acres needing that treatment, not to all rangeland in the major land resource area.
Source: 1982 National Resources Inventory.

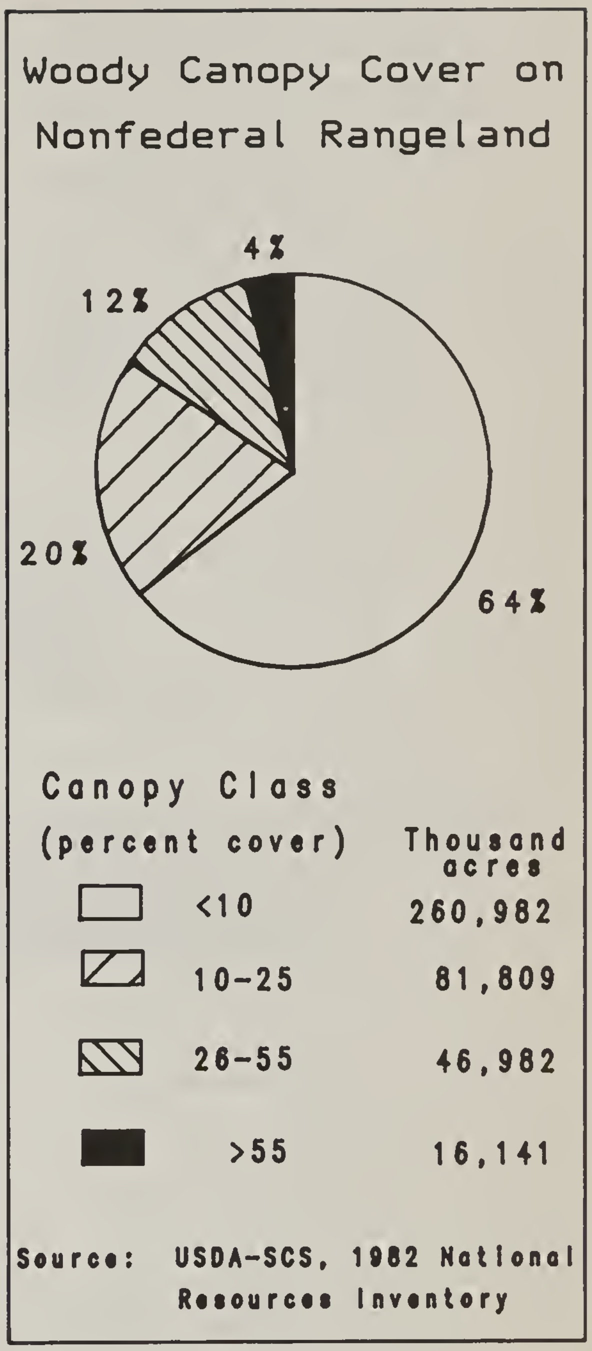
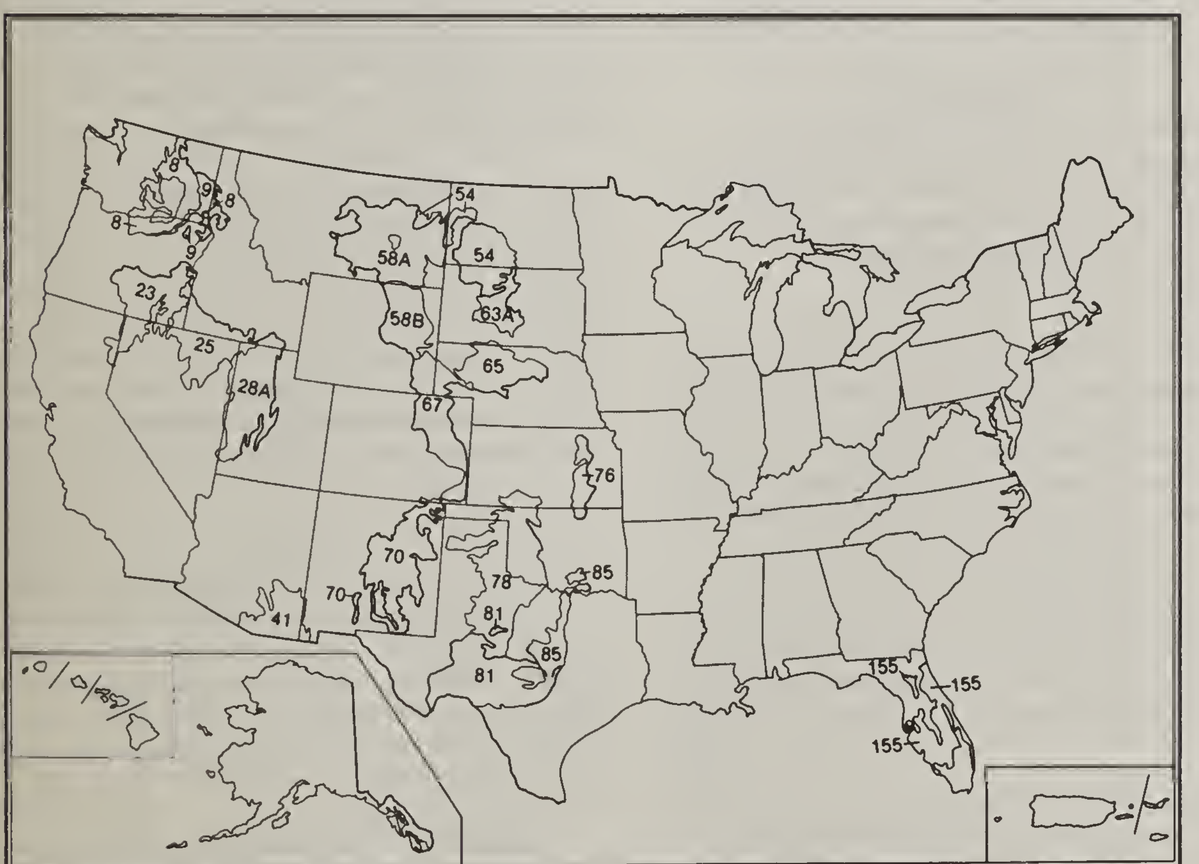


Figure 36.--Woody canopy cover on nonfederal rangeland, by canopy class.



Major land resource areas (MLRA's) for which data are presented in tables 13, 14, and 15. MLRA's are geographic areas having relatively homogeneous patterns of soil, climate, water resources, land use, and type of farming. There are 204 MLRA's in the Nation.

Range Improvement: Does Conservation Pay?

Range management practices enhance value of the range resource.
Range management practices protect range vegetation, prevent erosion, increase forage production, increase water yield and improve water quality, and improve wildlife habitat, esthetics, and recreation potential. The degree of improvement varies, depending on the characteristics of the site and its condition when a practice is applied. Some site-specific studies have attempted to quantify the multiple values resulting from improved range condition, conservation, and management. One study contracted by USDA has made an attempt to quantify the value of increased forage production across the western states.

Increased water yield.--The off-ranch benefits of conservation can be quite positive and dramatic, as in the case of the Rocky Creek watershed in western Texas. In the early 1960's, landowners on five ranches covering about one-half of the watershed began an extensive range management improvement program. By 1970, springs dormant since the 1930's had begun flowing on all five ranches. The West Rocky Creek watershed, which makes up only 3 percent of the acreage, now supplies approximately 7 percent of the water supply of San Angelo, 20 miles away.

Besides brush control and range reseeding, the ranchers instituted a program of grazing management that would enhance the cover of grasses on the watershed. As a result, the rangeland is providing an estimated 2,000 to 2,500 pounds of forage per acre, mostly grasses. The grasses help to hold soil and water on the land, reducing sedimentation of downstream water supplies and allowing water to soak into the aquifer. Grasses also retard the reinvasion of brush, although the ranchers must also do periodic brush-control maintenance work.

All of the conservation work was done in a manner that would benefit whitetailed deer and turkey--both valuable for hunting.

Wildlife management.--Economic pressure is compelling many ranchers to seek ways of making their operations more profitable. Concurrently, outdoor recreation and tourism are rapidly becoming the largest growth industry in the Rocky Mountain states. In Colorado, one ranch in five has already diversified into tourism. Ranchers all over the West are realizing that wildlife and wildlife habitat can be an income-producing asset. The lease of hunting and fishing rights has been an established source of income in southwestern and south-central Texas since the 1930's. In 1984, gross income from hunting leases averaged over $4 per acre in the Rio Grande Plains and about $3.25 per acre in the Edwards Plateau. 1/ These areas are so attractive to deer and quail--and to hunters--that 12 percent of landowners found it worthwhile to provide supplementary feed for wildlife at a cost of $1,500 to $20,000 per year. The same study made the point that in the Rocky Mountain states much of the land on lower slopes, valley floors, and foothills, which provides the necessary winter range for big game, is privately owned. These private lands are "critically important to wildlife populations and wildlife oriented recreation." 1/

Recreation.--A University of Wyoming research survey found that ranches and farms in Wyoming offered a remarkable variety of recreational pursuits to residents and out-of-state visitors. 2/ Besides hunting, fishing, and trapping, the farmers and ranchers responding to the survey mentioned swimming, horseback riding, hiking, camping, summer vacationing, cross-country skiing, snowmobiling, and special interests such as photography; collecting artifacts, rocks, and fossils; and historical and geological tours. Ranchers' attitudes also varied widely.

1/ Dwight E. Guynn and Don W. Steinbach, "Wildlife Values in Texas," Texas Agricultural Extension Service (1986), photocopy.

2/ Jeff Powell, Susan Bahr, and Kathy Green, "Wyoming Farm and Ranch Recreation Enterprises" (draft, 5 October 1986), photocopy.

Hunting big game--deer, antelope, and elk--was the major activity for which fees were charged, but one-third of the ranchers allowed it without charge. Two-thirds made no charge for camping, fishing, or hunting waterfowl or upland game birds. Some ranchers, on the other hand, did not allow any hunting or access to their land. Those who charged the highest fees typically offered seasonal package plans to nonresidents, including lodging, meals, outfitting, and guides. Most ranchers said they would like various forms of educational assistance in setting up or improving their outdoor recreation enterprises.

Diversified land use.--On a ranch in western Nevada, proper management of the native vegetation produced a bonus by enhancing the beauty of the landscape. The scenic attraction of flourishing wildflowers, trees, and grass brought requests from city dwellers for vacation home tracts. Instead of selling land, the rancher chose to sell easements with certain stipulations that would not allow interference with the livestock operation. This arrangement has worked well for all concerned. The tenants have access to the entire ranch for outdoor activities and have been an asset to the rancher by providing volunteer help.

Range management practices that increase forage production can increase ranchers' profits.
USDA contracted a 17-state study that attempted to quantify the value of the relative effects of four conservation management systems on forage production. 3/

3/ Fowler, J.M., McDaniel, K.C., and Creel, B.J. 1986. Estimates of 1982 organization, costs and returns of cattle and sheep ranches, by states, within the western region. Draft supplemental report #1.

_. Organization, costs, and returns from grazing management and conservation practices on livestock ranches, by major vegetation ecosystems and states in the western region, 1982. Draft supplemental report #2.

The four management systems are: (1) grazing management; (2) brush control and grazing management; (3) vegetative reestablishment and grazing management; and (4) brush control, vegetative reestablishment, and grazing management. On all ranch sizes, the analysis estimated that implementation of grazing management alone would yield the largest increase in net returns (fig. 37).

Although the analysis indicates conservation can increase profits, these increased gains in production and net income are not immediate. Rangeland generally responds slowly to management. For example, the response time for vegetative reestablishment (range reseeding) is 1 to 2 years in wetter sites and 2 to 3 years in drier sites. In some instances, the time required to recover application costs may take as many as 10 years.

Factors such as the rancher's management style, capital availability, and investment position influence the net returns that can be achieved by applying conservation practices. Because vegetation in some geographical areas responds more quickly than in others to improved management, the estimated increase in net return was larger where the dominant vegetation is tallgrass prairie (Kansas, Oklahoma, and Nebraska) than in areas that support mostly desert plant communities, such as Arizona, New Mexico, and western Texas.

Rangeland conservation to improve forage can help a state's economy. The study described above also estimated the effects of adoption of range management systems on the overall economies of each of the 17 western states. For each state, the economy was divided into 21 sectors, each related to ranching either directly or indirectly. In all states, grazing management was estimated to increase relative efficiency and production. The estimated degree of improvement varied from state to state; the average improvement achieved by adopting these improvements was about 14 percent.

This aggregate analysis suggests that an increase in final demand for range livestock products could improve the economy of each of the 17 western states. However, the full impact on income, employment, and economic output would vary by state.

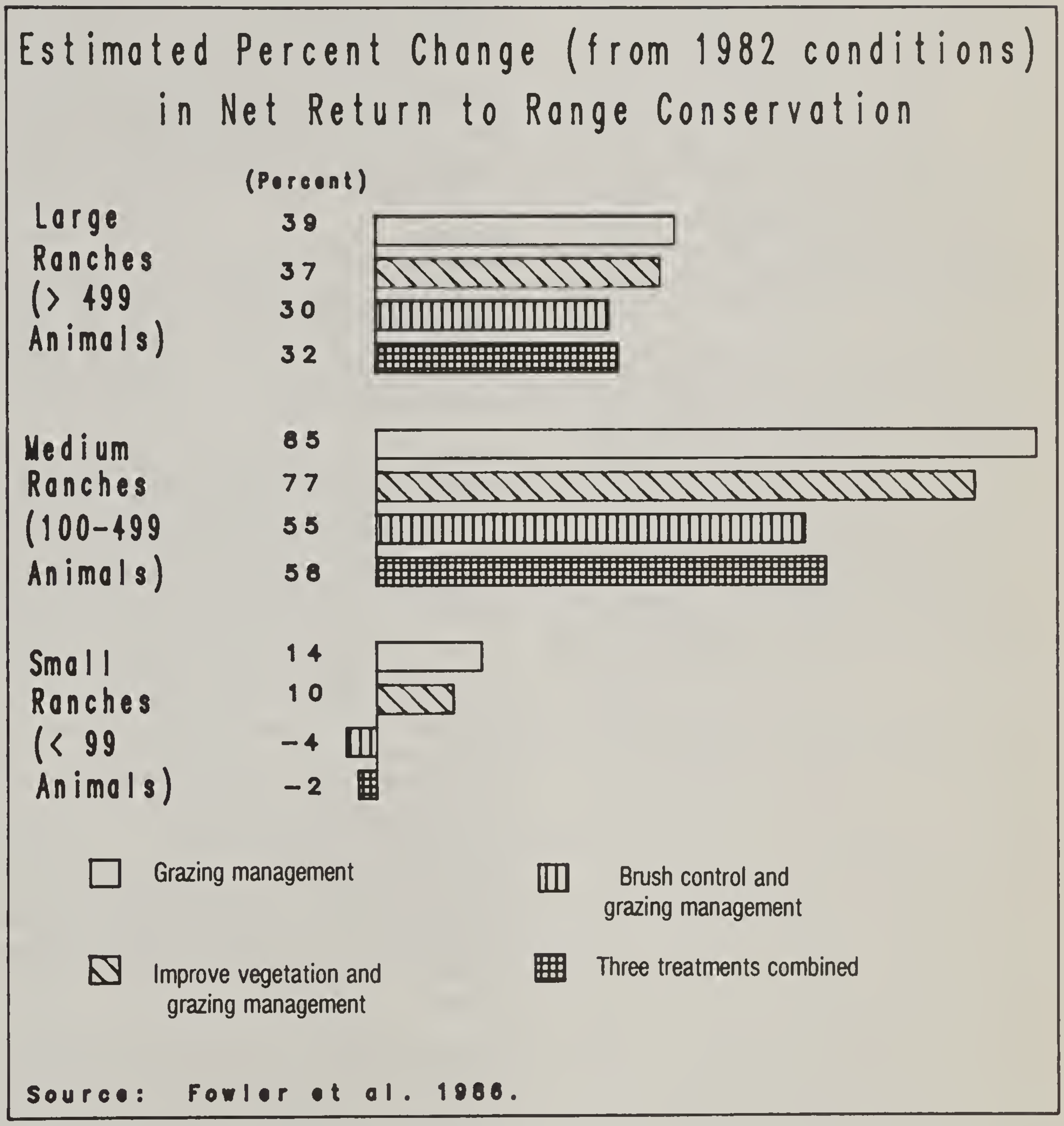


Figure 37.--Estimated percentage change in net return resulting from implementation of each of four conservation systems on small, medium, and large cattle ranches in western states.

The figure shows percent change in net returns from 1982 conditions. Results shown are averages based on typical ranch budgets developed to represent situations in each of the 17 western states. The budget year represented is 1982, midway between the 1979-80 peak and the 1984-85 trough in cattle prices. The drop in land prices from the 1982 level is not fully reflected. The budgets include the ranch's livestock inventory, the organization and value of resources, cash and non-cash receipts, and costs. Net income was defined by returns to the operator for labor, management, and capital. A partial budgeting technique, which traces the effect of changing one factor, was used to analyze changes in costs and production that might result from implementing the management practices. See appendix tables 35 and 36.

COOPERATIVE COORDINATED LOCAL, STATE, FEDERAL EFFORTS ARE PROTECTING RANGELAND MORE EFFECTIVELY

Idaho. A resource conservation and range development program, funded by the state legislature, provides low-interest loans for ranchers to improve practices on seriously degraded grazing land. The Idaho Soil Conservation Commission will administer the program. SCS will provide technical assistance through soil conservation districts.

Kansas. Since 1978 Kansas has developed a number of county and areawide range-forage-livestock programs. Committees identify problems and management solutions to be promoted and demonstrated. The program is a cooperative effort of many agencies and groups: Kansas State University, the Agricultural Extension Services, Kansas State Board of Agriculture, Kansas Fish and Game Commission, Agricultural Research Service, local conservation districts, local RC&D councils, county livestock associations, local extension councils, and SCS.

Montana. Rancher-run county rangeland committees are promoting conservation through local workshops, tours, seminars, and educational programs directed toward ranchers, students, and agricultural loan officers. Also, in 1985, 34 groups were coordinating federal, state, and private efforts to plan and implement grazing systems to improve rangeland. The State also provides low-interest loans for rangeland improvement.

Nevada. Because 84 percent of the state's land area is in federal ownership, and because private and federal grazing are interrelated, Nevada has developed an approach called Coordinated Resource Management and Planning. This process, based on the philosophy that problems are best solved at the local level by direct communication among all interested groups and individuals, has been used to develop plans that take into account the rights, obligations, and interests of all resource users and the needs of the resources themselves.

New York. Extensive acreages are in transition from pasture to native species and are not routinely fertilized, overseeded, or irrigated. State and local governments are promoting the use of these idle resources to improve income and the quality of life in rural areas. New intensive-use pasture technology is proving to be culturally and economically sound. Dairy and beef animals and sheep can be productively maintained on intensive pasture for about 180 days a year. Extended use of pasture would greatly reduce pollution from stockpiled manure and would permit sizable acreages of highly erodible marginal cropland, now used to produce silage corn, to be shifted to permanent pasture. Winter feeds could then be grown on the best, least erodible ground.

Pennsylvania. Demonstration grassland management farms are established in 14 southwestern counties, funded by special Agricultural Conservation Program funds. The Cooperative Extension Service also is actively involved in the program. SCS is cooperating with Delaware Valley College of Science and Agriculture in funding a demonstration intensive grazing system on the college farms.

Utah. Approximately 92 percent of the state's total land area is used for grazing. By focusing the resources of agencies and individual ranchers on areas where problems are greatest, over 1 million acres of rangeland have been improved in the past 5 years. Erosion has been controlled on more than 200,000 acres for an annual savings of more than 700,000 tons of soil, and sediment levels have been significantly reduced in several streams and rivers.

CHAPTER 6
Water Management Increases Usable Supply

In arid regions, crop production depends almost entirely on irrigation. Irrigated agriculture accounts for more than 40 percent of all freshwater withdrawals in the United States and consumes nearly three times as much water as all other uses combined. In subhumid and semiarid regions, agricultural production depends on water storage and distribution systems. Even in humid areas, droughts during the growing season are common and can significantly reduce yields.

Although localized or wide-scale water shortages of varying intensity and duration are occurring at times in most parts of the Nation, most problems could be reduced with careful planning. Improved management of irrigation water, improved management of soil moisture, and increased storage to increase dependable supply can bring supply and demand into better balance. Some improvements are being implemented.

Farmers have increased their efficiency in using irrigation water; a national average of 47 percent of the water withdrawn from surface or ground sources for irrigation was consumed by crops in 1985 as opposed to 41 percent in 1981.

On nonirrigated land, especially in areas of limited rainfall, farmers can make more water available for their crop by increasing infiltration and reducing runoff. Use of practices for soil conservation/soil moisture management can reduce erosion and increase net returns but must be monitored for possible effects on ground water quality.

Competition for water will intensify in the future if current trends continue. By 2030, four of the 18 water resources regions (Texas-Gulf, Rio Grande, Lower Colorado, and Great Basin) will not have sufficient water supplies, even in an average year, to meet nonagricultural needs and permit continued irrigation of the acreage currently developed for irrigation.

Will Agriculture Have Enough Affordable Water?

Agriculture is the marginal off-stream user of water resources. The net value of water used for irrigated agriculture is not high enough to compete with the values of water used for industrial or domestic purposes under free market conditions. Nonagricultural consumptive uses are expected to triple in the next 50 years. As these demands increase, water will be bid away from agriculture.

Each day, about 309 billion gallons of freshwater are withdrawn from surface or ground water sources in the contiguous 48 states for human use. Slightly more than 130 billion gallons are withdrawn for use in agriculture (fig. 38). The amount of water withdrawn for purposes other than agriculture has changed only slightly since the early 1970's. The amount of water used for agricultural production has decreased slightly since about 1975.

Slightly more than 200 billion gallons of the total withdrawn are returned to surface or ground water and are available for reuse. About 105 billion gallons are consumptively used — that is, they are incorporated into products, evaporate, or percolate beyond the area of reuse. Irrigated agriculture consumptively uses 78 billion gallons, and livestock production uses 2 billion gallons per day. In recent years, both industrial and agricultural users have increased their efficiency of use.

Water shortages of varying intensity and duration occur in many parts of the nation. Within the contiguous United States, 7.5 percent of the replenishable water supply is depleted. This percentage is expected to increase to 10.7 percent in the next 50 years, exclusive of any changes in agricultural water use. Depletion in humid regions is less than the national average, but in arid regions, almost all of the total replenishable supply is depleted.

When U.S. Geological Survey personnel, in consultation with state and local officials, prepared state water-issue summaries in 1983, they found that the availability of surface water or ground water in adequate quantity is a concern in most states. Twenty-nine states cited temporary, drought-caused shortages of surface water supplies as a problem, and 17 states reported increasing competition for the developed supplies (those stored in reservoirs and administered via diversions and conveyance structures).

There is widespread concern that existing uses will be hampered by water shortages. Supplies are not adequate to meet instream flow required for waste-load assimilation, fish and wildlife habitat, and navigation and predicted increased demands for withdrawals. Appendix table 39 shows where streamflows fall short of requirements--that is, where problems exist and are likely to occur.

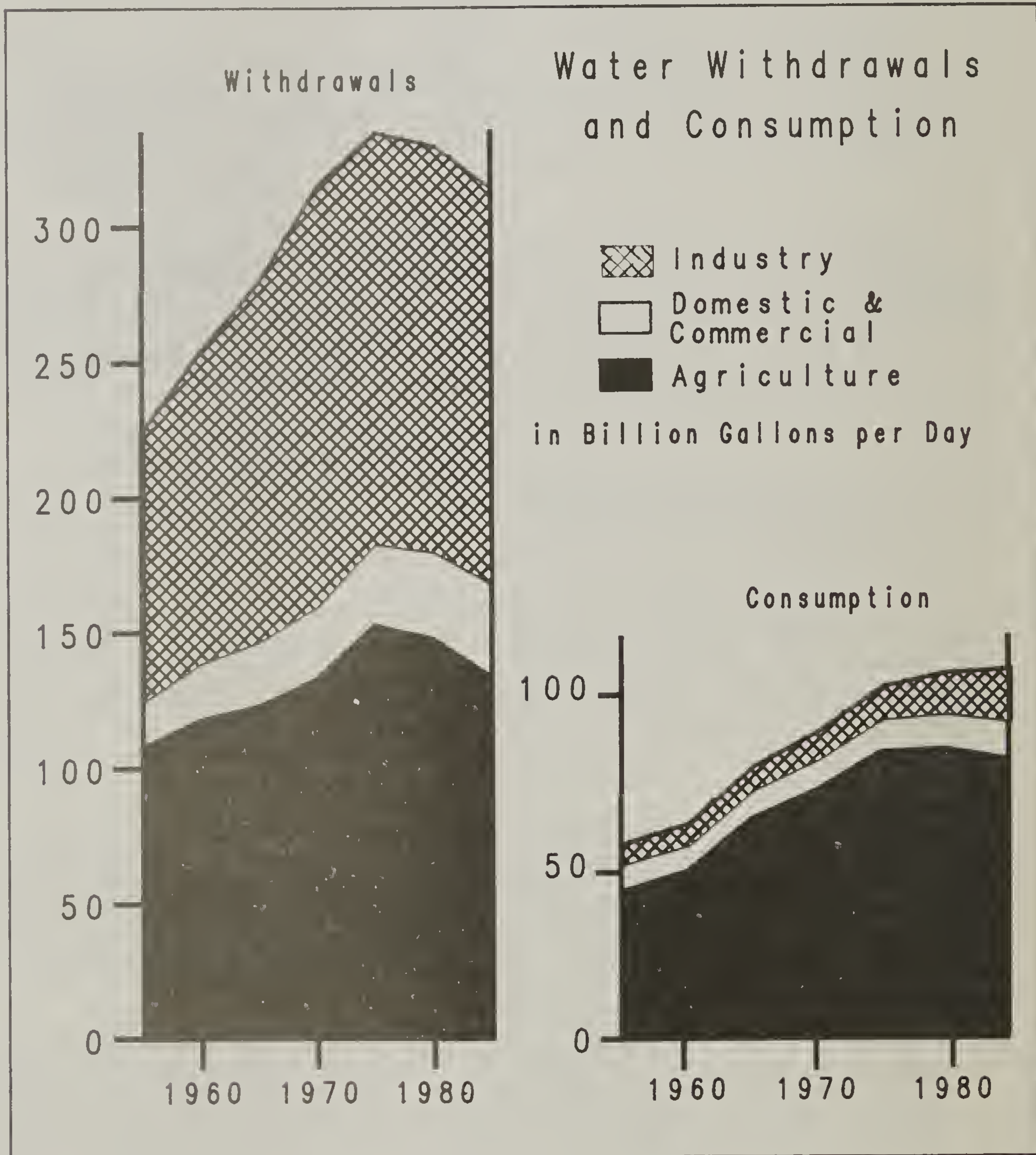


Figure 38.--Water withdrawals and water consumption in the United States, by functional uses. See appendix table 39.

Flows diverted for offstream uses seriously deplete streamflows in many subregions, even in average years, or will do so before the turn of the century (fig. 39). Offstream uses deplete the Lower Colorado and Rio Grande so much that some forms of aquatic life once found in these regions have disappeared. In the Great Basin, some forms of aquatic life are dying out. Projected offstream uses in the Texas-Gulf cannot be met without continued rapid ground water overdraft or dewatered streams.

Many states are relying on ground water to meet most of their projected increases in water use, but ground water availability is an issue in 47 states. The most common problems of ground water availability are water-level declines caused by intensive pumping (35 states) or increasing competition for available ground water supplies (26 states). The ground water level inevitably falls in the vicinity of a well that is being pumped, but this drawdown does not necessarily mean that ground water supplies are being significantly depleted. The state water-issue summaries cited only those declines that are progressive or are extensive in area, that cause significant decreases in streamflow, or that are in conflict with state regulations (fig. 40).

Major areas of ground water decline are concentrated in the irrigation-dependent Southwest. Some declines have interstate ramifications because pumpage in one state can cause water-level declines in an adjacent state. Ground water mining--withdrawal at a rate that exceeds long-term natural recharge--and the resulting lowered water tables increase pumping lifts and costs and may contribute to land subsidence, diminished streamflows, and salt water intrusion into fresh water aquifers.

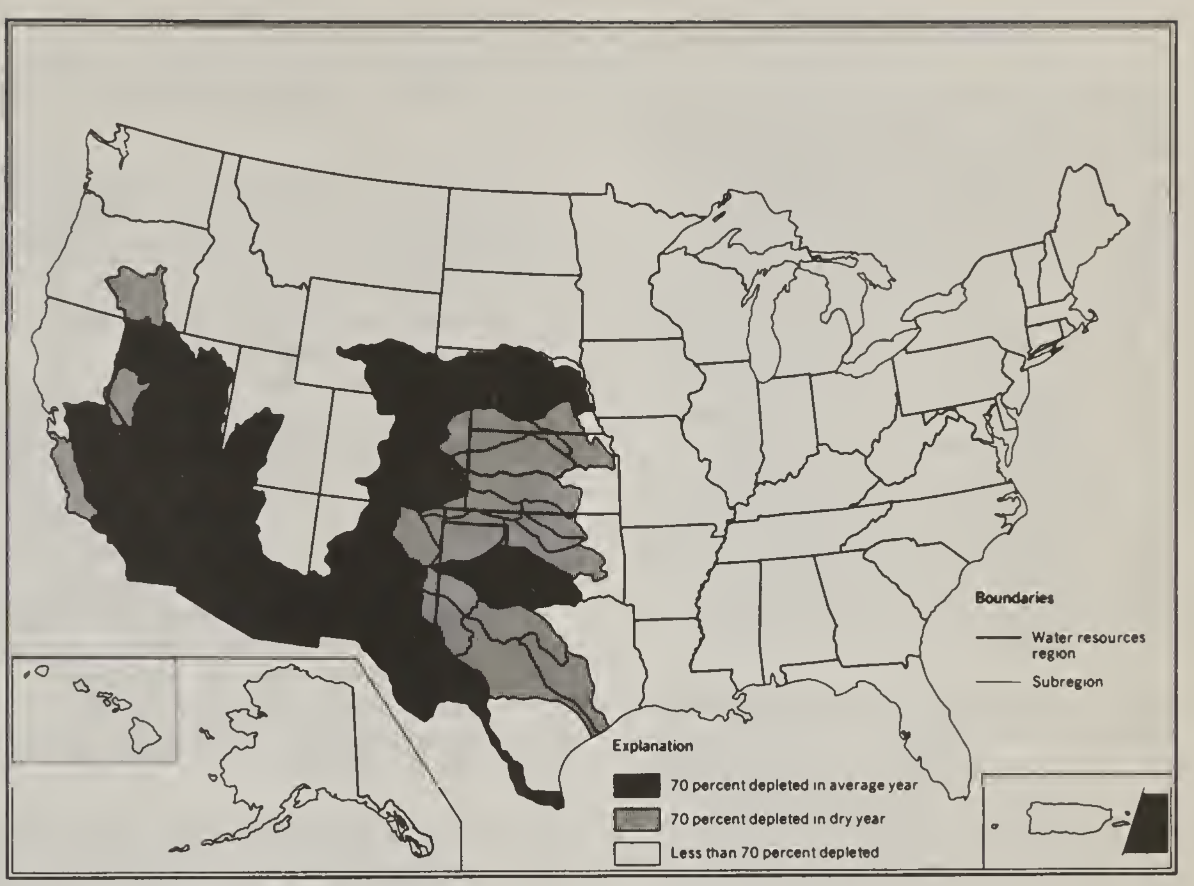


Figure 39.--Water depletion areas in the United States.

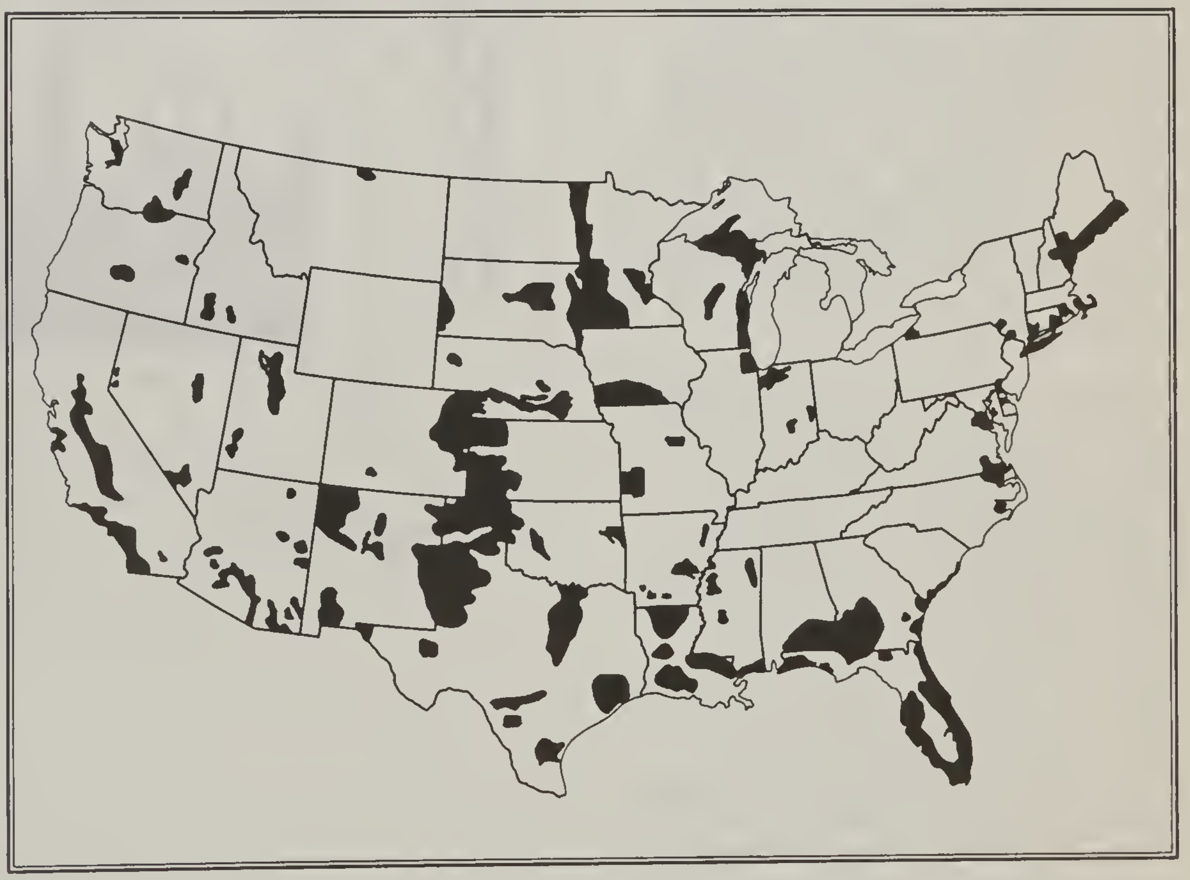


Figure 40.--Areas where ground water decline is of state or local concern.

Causes of Water Shortages

Shortages are most likely to occur where water supplies are chronically scarce, precipitation is erratic, streamflows fluctuate widely, water requirements have sharp peaks or seasonal variations, or demands at current prices are equal to a large part of the supply. More than one of these conditions can and frequently does occur in the same area. Shortages result in inadequate water supplies for irrigation and other offstream uses, diminished streamflows for aquatic life and hydropower generation, and overdrafts of ground water.

Shortages resulting from scarce supplies are likely to be prevalent in areas that are underlain by aquifers yielding less than 50 gallons per minute per well and that have less than 1 inch of annual runoff (fig. 97). Generally, areas receiving less than 20 inches of precipitation a year have less than 1 inch of runoff (see fig. 98).

Shortages resulting from wide fluctuations in supplies occur where precipitation and the resulting runoff and streamflow vary during the year and from one year to the next. In humid areas, periods of abnormally low rainfall may last several weeks or longer; in arid and semiarid areas, long droughts may extend well beyond a growing season.

Shortages can result from fluctuations in demand. Each water use has its own water demand--the amount of water of acceptable quality needed at a particular location for use at a given time and a given price. For example, livestock use and domestic use vary markedly during the day. Domestic use is lowest during the night and peaks at 8 a.m. Peak use for livestock operations occurs during feeding and cleanup periods and when animals come in from the field. Most irrigation water is applied immediately prior to and during the growing season, peaking in summer, which generally is the season of low streamflow (see fig. 101). Demands for water and competition for limited supplies increase with population and economic growth.

Water Supply and Use Vary Among the Water Resource Regions

Data on national totals and average conditions do not describe conditions in local areas and under actual weather conditions. Supply varies greatly among regions. For example, the Tennessee region has an area of 27 million acres and an average outflow of about 41 billion gallons per day (bgd) in a normal water year, 36 bgd in a dry year. The Texas-Gulf region has an area four times the Tennessee and an average outflow of 36 bgd in an average year but only 19 bgd in a dry year.

The Texas-Gulf region's annual streamflow is far more erratic than the Tennessee region's.

Although average annual streamflow in a wet year may be nearly as great in the Texas-Gulf region as in the Tennessee, average monthly flows-- the dependable supply-- are far less in the Texas-Gulf.

Water use differs greatly in the two regions. Offstream consumptive water use is higher in the Texas-Gulf region. The climate there allows farmers to harvest two or more crops a year from the same land. Crops and livestock use more water in warmer and less humid climates. Agriculture in the Texas-Gulf region depends heavily on ground water to meet its year-round needs. Instream flow requirements are high in the hydropower-producing Tennessee region: 94 percent of average annual streamflow.

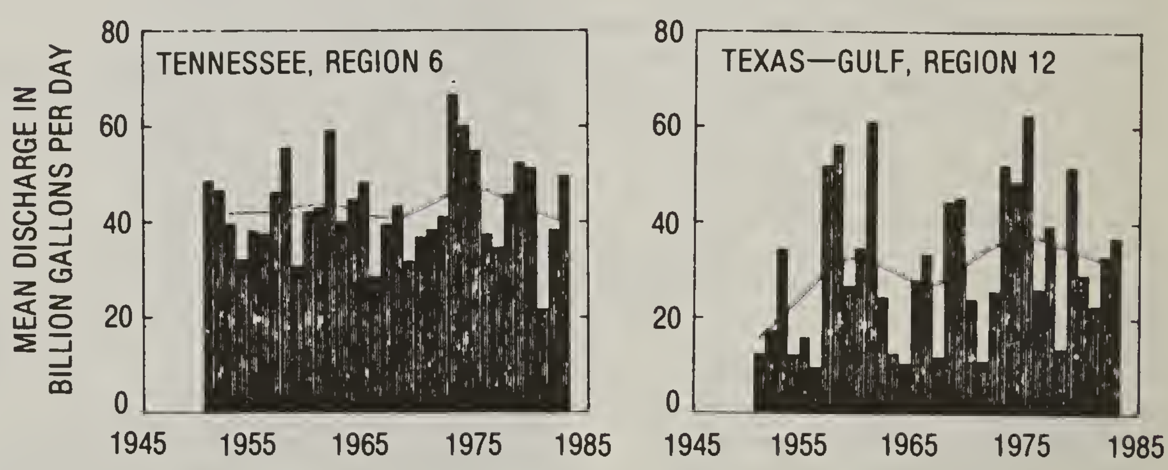


Figure 41.--Yearly and monthly streamflows, 1950-82, in two water resources regions.

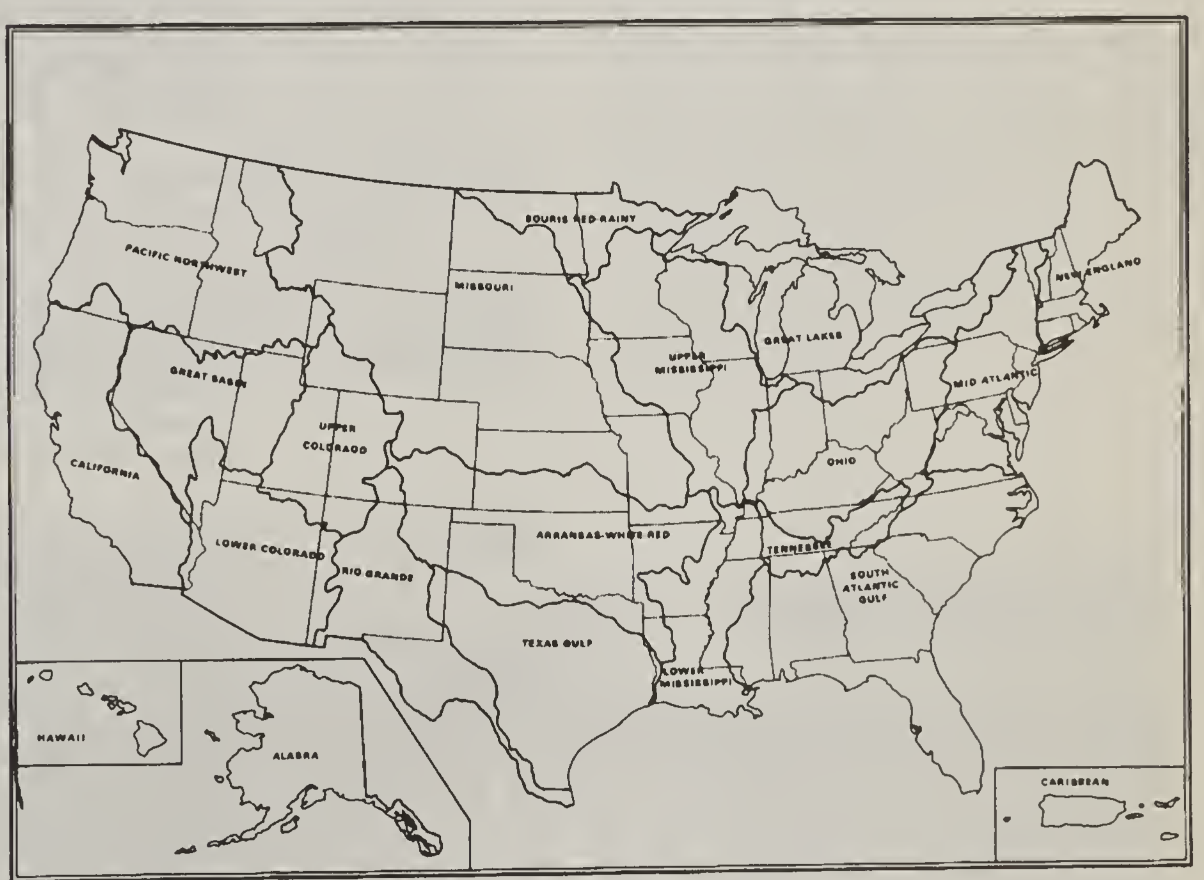
Nearly two-thirds of the fresh water withdrawn from surface sources and subsurface aquifers returns to the water supply and is available for downstream use. The rest is consumed--lost to the atmosphere through evapotranspiration or incorporated into plant or animal tissue or manufactured products. Competition for water is keen where consumptive use is high in proportion to the renewable supply. The average ratio of use to supply is 37.4 for the nine western water resources regions (table 16) average. In the nine eastern regions, the ratio of use to supply is only 2.8.

Discussing water supply problems in terms of national totals and average conditions can mask problems that are severe in local areas and under actual weather conditions.

Table 16.--Average consumptive use and renewable water supply in western water resource regions, 1985

Water resources region	Total consumption 1/	Renewable supply	Ratio of consumption to renewable supply
	(million gallons per day)		(percent)
Missouri	21.3	61.5	34.6
Arkansas-White-Red	9.8	67.7	14.5
Texas-Gulf	10.4	35.6	29.2
Rio Grande	3.8	5.3	71.7
Upper Colorado	3.5	13.9	25.2
Lower Colorado	5.0	9.4	53.2
Great Basin	4.1	6.0	68.3
Pacific Northwest	15.6	268.5	5.8
California	23.0	68.1	33.8

1/ Includes net evaporative losses.



How Can Agricultural Water Supplies Be Used More Effectively?

There are two approaches for increasing the capabilities of our water supplies to meet demands:

o Demand management--reducing water requirements,

o Supply management--changing the quantity of water available.

Table 17 summarizes potential ways to conserve and supply water. Demand management (through improved irrigation water management and limited irrigation) and supply management (through ground water storage and soil moisture management) are discussed in detail in the following pages. New ideas and technologies are being developed in both fields.

Table 17.--Potential ways to deal with water shortages

	DEMAND MANAGEMENT
Reduce Non-Beneficial Evapo-transpiration	o Irrigation Water Management (IWM): Provide information on when, how much, and how to apply irrigation water. o Measures to Increase Irrigation Efficiencies: Install physical measures such as canal lining, piping, land leveling, control structures, improved and automated irrigation systems, etc. o Reservoir Evaporation Suppression: Use chemical films to impede escape of water molecules from the liquid to air. o Measures to Reduce Water Use by Phreatophytes and Other Non-Economic Vegetation: Clearing, thinning.
Reduce Crop Water Requirements	o Reduction in Acreage of Irrigated Crops: Convert irrigated cropland to dryland. o Decision-making Information and Models: Use data on water availability and other factors to recommend location, acreage, and type of plantings. o Crop Stress: Provide less than optimum water requirements (limited irrigation, alternate rows). o Crop Variety Selection: Select drought resistant strains that can withstand dry periods.
	SUPPLY MANAGEMENT
Store Runoff Water	o Surface Water-Ponds and Reservoirs: Catch and retain floodwater for release during droughts. o Groundwater Recharge: Convey or confine surplus runoff to recharge areas, to increase supply that can later be withdrawn.
Increase Water Yield	o Water Harvest: Construct impermeable surface to reduce infiltration and store runoff. o Vegetative Management: Manipulate vegetative cover to increase runoff.
Capture and Retain Precipitation	o Snow Management: Snow fences, selective cutting, etc. in high mountain areas and tall-grass strips, etc. on cropland to collect snow and retard snowmelt o Soil Moisture Management: Cultural (conservation tillage) and mechanical (level terraces) practices to decrease evaporation and increase moisture available in soil profile for plants. o Increase crop rooting depths to expand their reservoirs: by breaking hardpans, liming acid soils, and selecting crop species and varieties that root more deeply. o Vegetation Management to increase infiltration rates. o Riparian Management to maintain higher water tables.
Add to Available Water Supply	o Inter- and Intrabasin Transfers: Divert water from areas with surplus water to water-short areas. o Use of moderately saline drainage water on soils suited to long-term use. o Renovation of wastewater effluents for agricultural production. o Transfer water from lower valued to higher valued crops or uses.

Manage Irrigation Water Efficiently

Although farmers irrigated nearly 20 percent more land in 1982 than in 1975, they used only about the same amount of water. Irrigation water use per acre was lower in 1982 because:

o Irrigated farming has shifted in part from arid to more humid regions, where precipitation fills much of the crops' water requirements.

o Conveyance losses have been reduced by increased use of lined canals and onfarm water sources.

o Onfarm distribution and application systems have been improved or new ones introduced, such as laser-beam field leveling, surge-pulse irrigation, and drip systems.

o Irrigation water management is more sophisticated, making use of computer-aided scheduling, risk acceptance, and cost-reduction objectives.

In recent years, the tight farm economy and higher pumping costs have checked the increase in irrigated acreage in water-short areas and increased the incentive to improve irrigation efficiency.

Irrigation efficiency is defined as the volume of applied water in the root zone used by the crop, expressed as a percentage of the volume of water pumped from the ground or diverted from a surface water source. The national average, which was estimated to be 41 percent in 1975, was estimated to be 47 percent in 1982. The 1980 RCA Appraisal estimated that that much improvement could not be achieved until the year 2010, given expectations at that time.

According to the 1982 National Resources Inventory, improvement of irrigation water management was still needed on 17 million acres--about 29 percent of all irrigated cropland and pastureland--to control erosion, reduce water losses, synchronize water applications with crop needs, or correct saline or alkali soil conditions. 1/

The main components of irrigation efficiency are:

o off-farm conveyance--from the water diversion point to the farm,

o on-farm distribution--from the farm headgate or farm irrigation well to the application facility (sprinkler line, border strip, or group of furrows),

o application--from the application facility to uptake by the crop and to soil storage in the root zone, and

o management--operation and use of the irrigation system.

Off-farm conveyance efficiency is defined as the volume of water delivered to the farm, expressed as a percentage of the volume of water pumped from the ground or diverted from a stream or other water source. Irrigation districts and other suppliers of irrigation water have increased the average conveyance system efficiency from 78 percent in 1975 to an estimated 81 percent in 1982 (fig. 43), in part by coordinating the amount and timing of water deliveries with onfarm irrigation needs and by flow measurements, record keeping, and other actions.

Onfarm distribution and application efficiency is defined as the volume of applied water in the root zone that is used by the crop, expressed as a percentage of the volume of water delivered to the farm. Irrigators have improved onfarm efficiencies from 53 percent in 1975 to 59 percent in 1982 by adjusting to limiting physical factors and by effective water management. Water measurement devices, ditch maintenance, location and alignment of ditches, and lining of ditches affect onfarm delivery efficiencies (fig. 42). Land shaping and the selection and design of an application method suitable for the soils and slopes improve application efficiencies.

Improved management can increase both off-farm and onfarm irrigation efficiencies. Irrigators can improve efficiencies by scheduling use of water, timing the applications, and applying correct amounts of water. Irrigation scheduling services and other technical assistance can aid in making the best use of irrigation water supplies.

Figure 42.--Siphon irrigation from a concrete-lined ditch, on a field of onions in Colorado's Grand Valley.

1/ See chapter 9 for discussion of salinity problems related to irrigation.

Table 18 lists potential efficiencies of specific application methods. Irrigators may not achieve potential efficiencies because of physical factors--for example, soil intake rates and water-holding capacities may vary within a field, or the field slope-length relationship may be unfavorable--or because irrigation is used for leaching and other purposes unrelated to crop water requirements. Water conservation may be affected by institutional and social factors including water laws or court decrees, water prices, environmental conflicts, financial capabilities, and social attitudes toward land use.

Not all water "lost" because of inefficient conveyance and distribution is really lost. Most of the diverted water not used by the intended crops is returned to the stream system to become available somewhere downstream. Some of the return is overland; the remainder returns through underground flow (fig. 43). This underground return flow is a form of indirect storage that may result in beneficial extension of the time that a stream contains adequate quantities for downstream users.

The portion of the water taken for irrigation that neither produces the intended crops nor returns to the river basin water system is called "incidental loss". Nationally, the average incidental loss of irrigation water is about 13 percent of the diverted flow. As a practical matter, very little of the incidental losses can be prevented within existing physical and economic limitations.

Table 18.--Potential efficiencies and reported use (by acreage) of application methods

Gravity methods	Potential efficiency	Acres	Pressure methods	Potential efficiency	Acres
	(percent)	(million)		(percent)	(million)
Flood		9.0	Sprinkle		20.6
Level border	90		Center pivot	82	9.4
Graded	80		Solid set	77	9.4
Guide border	70		Wheel/Handline	73	6.3
Contour ditch	60		Other: gun, etc.	65	3.7
Contour levee	70				
Flood	60				
Furrow (water delivered via gated pipe and open-ditch siphon tubes)		18.0	Drip Trickle		1.0
			Continuous Tape	90	1.0
			Point Source emitters	90	
			Spray emitters	85	
Graded furrow	75		Spray emitters	85	
Corrugations	80				
Subsurface	75	0.4			

Source: Potential efficiency based on USDA, SCS. 1-85. Water conservation effects of land treatment and irrigation. unpublished.
Acreage based on U.S. Department of Commerce, Bureau of Census. 12-85, 1984. Farm and ranch irrigation survey preliminary reports; and USDA, SCS. 1982 National resources inventory.

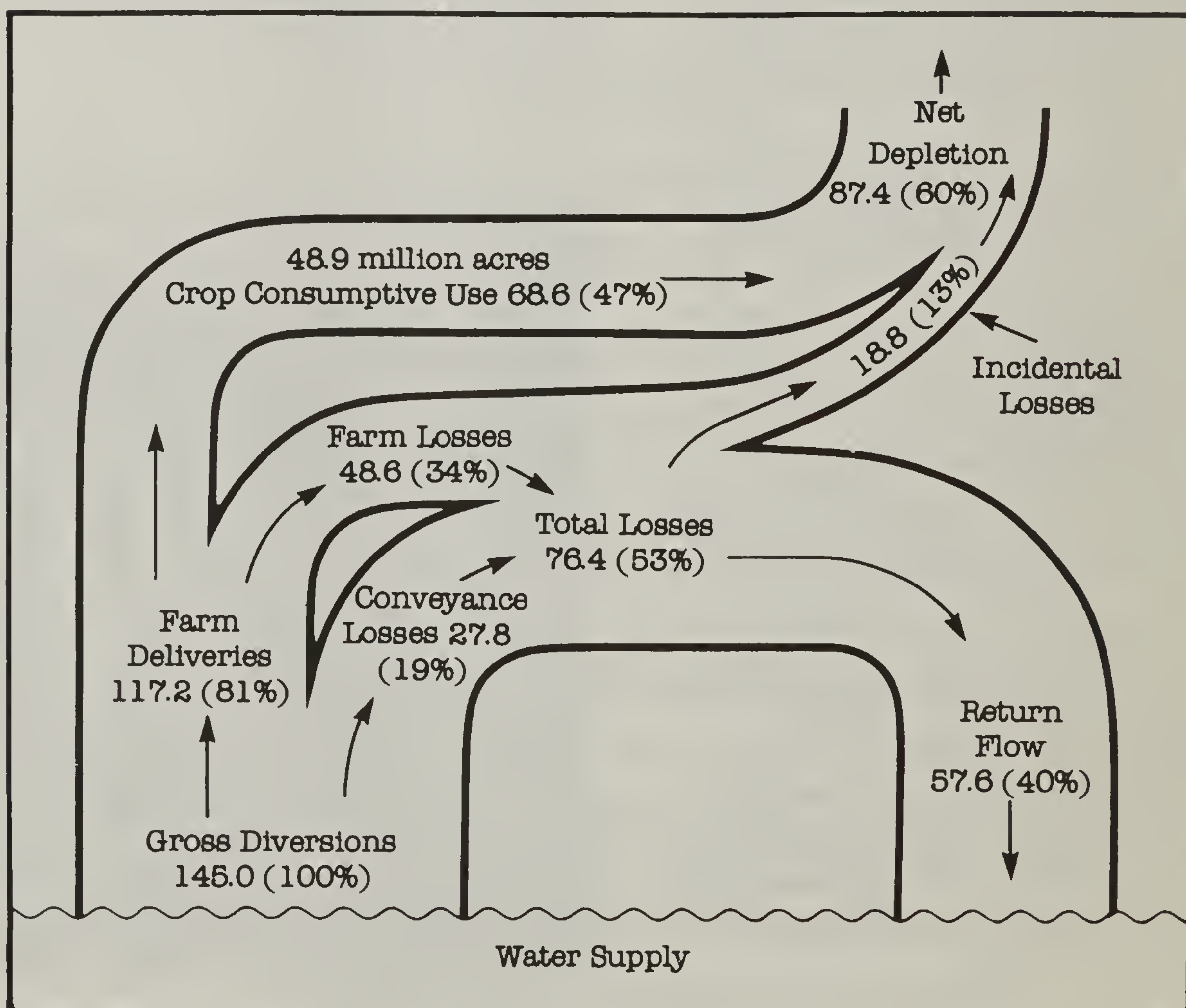


Figure 43.--Irrigation water budget for the United States and Caribbean--1985 average year. See appendix table 40.

Irrigated Land.--In 1982, 14 percent of U.S. cropland was irrigated. Some irrigation is practiced in every region (fig. 44). Over 90 percent of the water consumed by irrigation is used in the chronically dry regions of the West.

The rapid expansion of irrigated land and increase in irrigation water use has slowed during the last few years (fig. 45). In 1982, the Census of Agriculture reported a decline in the number of acres irrigated. Fewer acres were irrigated because lowered water tables and higher energy costs have markedly increased the cost of pumping water and because lower commodity prices have made irrigation less profitable.

In 1978 and again in 1982, 14 states had over a million acres irrigated. Of these, Nebraska and Arkansas irrigated more acres in 1982 than in 1978; the other 12 states irrigated fewer (table 19).

Irrigation is increasing in the East. A half century ago, nearly all irrigated acreage was in the 17 western states. By 1969, 4.3 of 39.1 million acres irrigated (11 percent) were in the eastern states. In 1982, 7.7 of the 49 million acres irrigated (15.8 percent) were in the eastern states. Arkansas and Florida together accounted for over 3.6 million acres--almost half of the eastern total.

Irrigation Projects.--At the turn of the century, more than 90 percent of irrigation water came from project facilities. Emphasis on project development began to weaken in the late 1930's. Interest was rekindled in the mid-1950's to 1960's, but the acceleration has declined in recent years. Now, only about 40 percent of the irrigated farmland receives water from project facilities. Federal entities, primarily the Bureau of Reclamation, constructed about half of these projects. The federal share of all irrigation investment has dropped from 40 percent in the 1950's to less than 20 percent in the 1970's (table 20).

Table 19.--Top 14 states (1982) and the number of acres irrigated, selected years from 1944 to 1982

State	Irrigated area 1944	1954	1964	1974	1978	1982
	1,000 acres					
California	4,952	7,048	7,599	7,749	8,505	8,461
Nebraska	632	1,171	2,169	3,967	5,683	6,038
Texas	1,320	4,707	6,385	6,594	6,947	5,573
Idaho	2,026	2,325	2,802	2,859	3,475	3,451
Colorado	2,699	2,263	2,690	2,874	3,431	3,193
Kansas	69	332	1,004	2,010	2,685	2,675
Arkansas	289	858	974	949	1,683	2,034
Montana	1,555	1,891	1,893	1,759	2,069	2,023
Oregon	1,129	1,490	1,608	1,561	1,880	1,809
Washington	520	778	1,150	1,309	1,639	1,638
Florida	222	428	1,217	1,559	1,980	1,584
Wyoming	1,354	1,263	1,571	1,460	1,661	1,565
Arizona	726	1,177	1,125	1,153	1,196	1,099
Utah	1,124	1,073	1,092	970	1,168	1,083
All other states	1,885	2,748	3,777	4,467	6,348	6,776
50 states, total	20,539	29,552	37,056	41,243	50,350	49,002

Source: 1978 and 1982 Census of Agriculture.

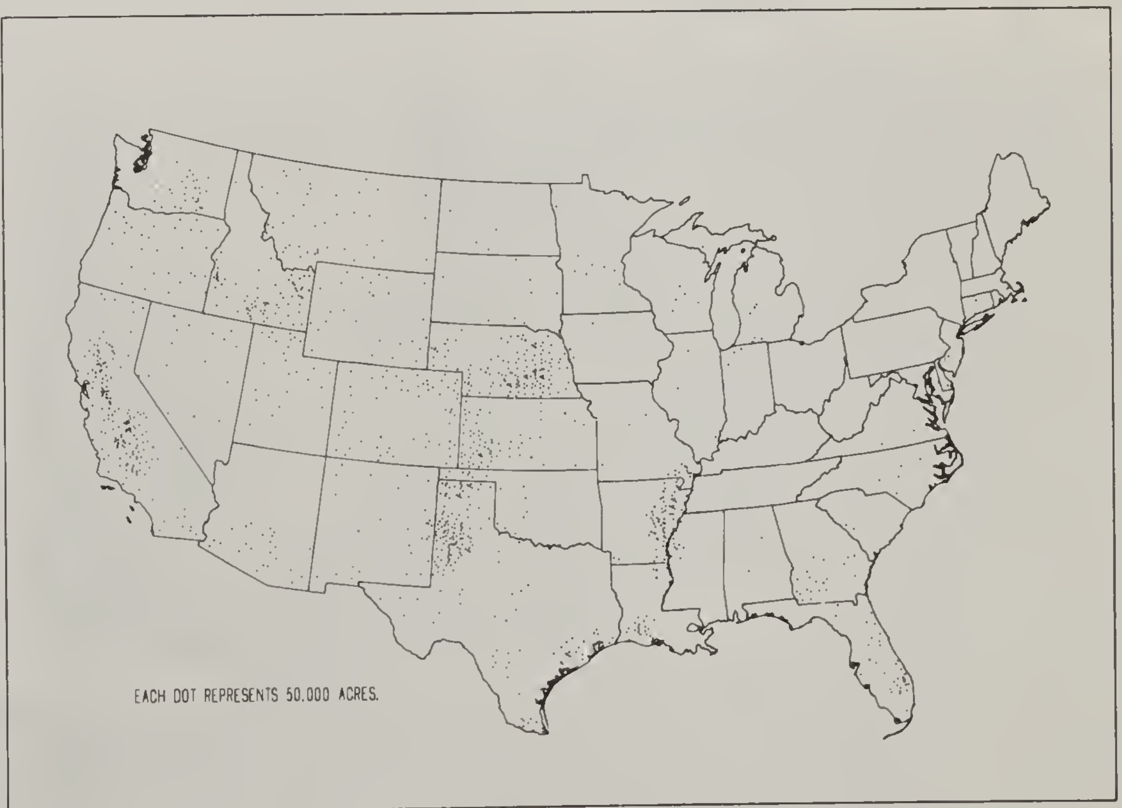


Figure 44.--Irrigated cropland (1982 NRI). The dot pattern is computer generated and does not show exact sites within a state. For additional data on irrigated acres, irrigation efficiencies, and water use, see appendix table 40.

Table 20.--Gross annual irrigation investment, 1951-80

Period	Nonfederal facilities		Federal investment	Total investment
	On-farm	Project		
	(million 1977 dollars)			
1951-1955	353	53	258	664
1956-1960	350	39	268	657
1961-1965	394	101	313	808
1966-1970	559	110	254	923
1971-1975	688	26	238	952
1976-1980	1,240	21	148	1,409

Source: Pavelis.

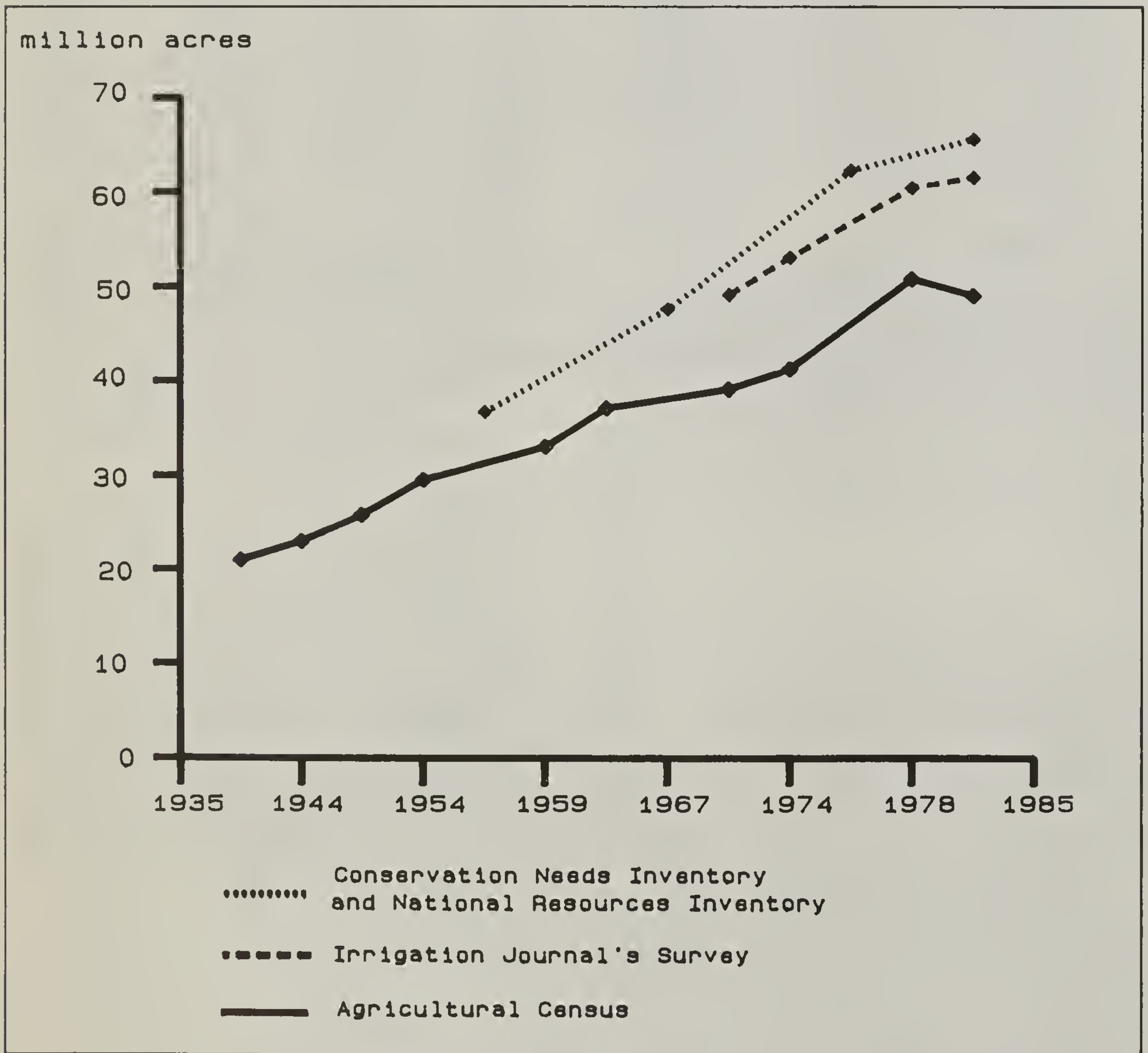


Figure 45.--Acreage of irrigated land, 1935-1982.

The three inventories in give different figures on irrigated acreage because they use different definitions and survey methods. The Natural Resources Inventory uses SCS personnel to record information for statistically selected sample points. The information includes the number of acres irrigated during the survey year or any 2 of the previous 4 years. Thus the NRI indicates how much land has irrigation systems in place. The Census of Agriculture uses a questionnaire to ask farmers how many acres they irrigated during the census year. The Irrigation Journal's data are estimates made annually by state irrigation and water quantity specialists. Both the Census and the Journal inventory attempt to record the land actually irrigated rather than the acreage prepared for irrigation.

Table 21.--Irrigated land (1982)

Water source	Acreage irrigated by	
	Pressure	Gravity
	(million acres)	
Ground water 1/	15.1	13.5
Surface water 2/	6.5	13.9

1/ Includes 4.6 million acres irrigated from off-farm irrigation wells.

2/ Includes 6 million acres irrigated from onfarm surface sources.

Practice Limited Irrigation

Limited irrigation refers to a moisture management strategy that integrates irrigation water with moisture from rainfall. The strategy is to apply limited amounts of irrigation water to achieve the greatest return per unit of water. The strategy includes using crops that transpire less water, changing the cropping system to match periods of high crop use with expected rainfall and carryover soil moisture, and letting the soil dry to near the wilting point before applying irrigation water. This last technique allows more capillary water to rise into the root zone and more rainwater to soak into the ground. Some farmers are changing their farm operations and adopting new conservation practices so that they can take full advantage of rainfall and use less irrigation water. Limiting irrigation water may, however, result in below-maximum yields.

Irrigation water can be conserved by planting drought-tolerant crops and cultivars that have the ability to recover from stress, and by adding the irrigation water only when it is needed (fig. 46). Technologies include selecting crops whose critical growth periods coincide with patterns of highest rainfall, using different plant populations and spacings (such as super-thick sorghum), retaining cover crops to use available moisture in the soil profile, using no-till or conservation tillage, leveling land, and placing small dikes in irrigation furrows to capture and hold rainfall.

Maintain Drainage Systems

Excess water is the dominant limitation on 309 million acres of nonfederal rural land. These soils, which are affected by poor soil drainage, wetness, seasonally high water tables, or overflow, are classified as "w" subclass (appendix table 1).

About one-third of the "w" soils are identified as wetlands. 2/ The preservation of wetlands, with their wildlife and other environmental values, has been a national and USDA policy since the 1950's. The swampbuster provision of the Food Security Act of 1985 reinforces that policy. Under the swampbuster provision, farmers lose eligibility for USDA support programs if they drain wetland areas for use as cropland. The provision does not apply to wetland areas drained prior to passage of the law.

About 233 million of the 309 million acres of "w" soils are used for agriculture. Of these, about 107 million acres are cropped.

In the past, installing drainage systems to improve soil water conditions to enhance production or ease of management has been a major component of agricultural development. The USDA Economic Research Service (ERS) estimates that about 150 million acres have been drained at least once since 1855 and that 100 million acres of wet soils had artificial drainage systems in place in 1985. About 65 percent of that land is drained by surface features only and 35 percent by a combination of subsurface and surface measures. About 65 percent of the farm area drained is served by outlets or other disposal facilities installed by drainage districts or other multipurpose organizations.

Aging drainage systems need repair.--In some areas where drainage systems were installed many years ago, the systems are no longer effective. The average life of an open ditch system is probably less than 20 years and of an underground system, less than 30 years. To maintain drainage systems on the acreage where they are already in place, an average

Figure 46.--A water district technician uses a probe to measure soil moisture in a California avocado grove.

2/ See chapter 11.

of 4 to 5 percent of the existing systems would need to be replaced each year.

Nearly 60 percent of the area drained at present has been drained since 1945. Nearly 40 percent has been drained since 1960. The replacement rate has been much less than 4 or 5 percent. Unless the replacement rate is much higher than 5 percent annually for the next 10 or 20 years, the acreage of drained cropland will decrease.

ERS estimates that, as of 1985, about 55 percent of all expenditures by drainage organizations had been for maintenance and replacement. ERS did not estimate maintenance expenditures by individual landowners.

Increase Dependable Supplies

Dependable water supplies are quantities of water that users can rely on with a stated frequency of chance of shortage. Dependable supplies can be increased by storing high flows and runoff in reservoirs or aquifers.

Increase Surface Storage.--The unregulated flow of many rivers varies from year to year or season to season. The rate of flow is many times greater during floods than during low flow periods, and some streams cease flowing during droughts. Even where the rate at which water withdrawn from a river is small compared to the average flow, there may be periods during which the desired supply of water is unavailable. Therefore, dependence on surface water as a source of supply usually requires an impoundment to store water for release during dry periods.

About 450 million acre-feet of storage have been developed. Analysts estimate that there is potential for about 750 million acre-feet of additional storage, but the costs of development would be high (appendix table 42). The most cost-effective sites for reservoirs have already been developed, and the rate of construction has decreased.

Increase Ground Water Storage.--Ground water is withdrawn at an average annual rate of 86 million acre-feet per year. In 1985 ground water constituted 31 percent of all fresh water withdrawals--up from 24 percent in 1975. Ground water supplies accounted for 47 million of the 87 million acre-feet consumed by irrigation.

Aquifers can be managed so that water in storage is reduced during peak consumption and replenished by recharge during periods of surplus water. Any technique that increases natural recharge to or decreases natural discharge from an aquifer will increase the stored ground water that can be withdrawn by pumping wells. Production wells can be located according to aquifer properties and boundaries and pumped according to calculated time schedules. The withdrawals induce changes in ground water movement, control the distribution of ground water in storage, and affect the nearby streamflow. The resulting changes in ground water and surface water can increase the supply that is available at the desired time and location.

Recharge beyond what would naturally occur is practiced in some areas to take advantage of the ground water storage. Artificial recharge is the process of replenishing ground water through human activities. It consists of manipulating input to the ground water reservoirs in addition to regulating pumping withdrawals. In the broadest sense, artificial recharge includes not only planned replenishment but also additions to the ground water that are

Table 22.--Rural land with drainage systems in place in 1985

States	Land drained	Percent of cropland drained
	(1,000 acres)	Percent
Illinois	9,795	35
Indiana	8,085	50
Iowa	7,790	25
Ohio	7,400	50
Arkansas	7,085	65
Louisiana	7,015	60
Minnesota	6,370	20
Florida	6,290	45
Mississippi	5,805	55
Texas	5,760	10
Michigan	5,515	30
North Carolina	5,400	25
Missouri	4,240	25
California	3,015	20
North Dakota	2,365	6
Wisconsin	2,245	10
South Carolina	1,755	25
Georgia	1,545	8
Maryland	1,210	30
Tennessee	1,150	15
Nebraska	1,005	7
New York	915	15
Delaware	460	25
Leading States	102,215	25
Other States	7,465	1
United States	109,680	20

Source: Pavelis, George A. (ed.) 1987. Farm drainage in the United States.

incidental to other activities; it includes not only good quality water but also any waste water that is added. Disposal of some nonconsumptively used water in septic tanks, pits and sumps, and seepage ponds also may replenish ground water supplies.

Artificial recharge may be used either to replace ground water where water levels have been drawn down or to temporarily increase local ground water storage for later recovery. Artificial recharge also can help to even out streamflow--that is, aquifers can be used to absorb flood runoff and release the water back to the stream as runoff subsides. During a drought or any period in which water demand increases, water supplies can be obtained by pumping wells.

Artificial recharge may be used used to reduce salt water encroachment, to prevent subsidence from worsening, and to improve water quality by filtering the water through natural sand and gravel.

Artificial recharge may be accomplished by direct and indirect methods. Direct methods of recharge include water spreading by means of ponds, check dams, pits, furrows, or ditches to increase the amount of water infiltrating from the surface into the ground water reservoir. Impounded surface water can infiltrate a permeable part of the aquifer that is exposed at the land surface. Water can be injected directly into the aquifer through wells or shafts. Indirect methods of recharge include inducing movement of water from streams or lakes into underground formations and preventing the natural flow of ground water to the land surface by lowering ground water levels.

In many places, irrigation water applied on permeable soils in natural recharge areas replenishes ground water. In some places, farmers apply water to leach soluble salts from saline or alkaline soils; this water also infiltrates to ground water. Even where water supplies are adequate, however, applying enough water to leach salts from soils can create new problems. For example, the reservoir in the Kesterson Wildlife Refuge in California collects excessive levels of selenium.

Aquifers have advantages over surface impoundments as reservoirs for cyclic storage of water:

- o They are relatively permanent.
- o They do not lose storage capacity through sedimentation.
- o They do not lose water by evaporation.
- o They are less vulnerable to destruction or contamination.
- o They pose no flood threat to downstream communities.
- o Their capacities are greater.
- o They can be used as a distribution system.

However, when ground water supplies do become contaminated, decontamination is far more prolonged and difficult than it is for surface waters. Aquifers that underlie rapidly permeable soils are most exposed to the risk of contamination. 3/

Most ground water recharge occurs on privately owned rural lands. Identification of areas underlain by significant aquifers, implementation of measures to improve percolation, delineation of recharge areas, and management of ground water can lead to wider use of ground water storage.

Improve Management of Soil Moisture

On nonirrigated land, especially in areas of limited rainfall, farmers can make more water available for their crop by increasing infiltration and reducing runoff. USDA has estimated the reduction in runoff that results from application of conservation practices and has used the Erosion/Productivity Impact Calculator (EPIC) and the Interactive Conservation Evaluation System (ICE) to estimate the effects that reducing runoff by specified increments would have on crop yields, erosion, and net returns to capital and management. The analysis shows that soil moisture management can provide highly desirable results in terms of crop yields, erosion control, and net profit. However, it also shows that it is quite easy to have negative effects on yield and easier yet to have negative effects on profits. A fairly sophisticated site-specific analysis will generally be required to determine which practices provide the most cost effective results.

Increasing infiltration can increase crop yields.--The effects of specific soil moisture management practices are difficult to study in field experiments because the effects of the various management actions and physical processes involved in agricultural production are interrelated. Soil moisture management practices affect soil moisture in various ways--through effects on runoff, infiltration, permeability, and evaporation. Those practices that increase infiltration may have potential for increasing ground water recharge as well.

For this appraisal, USDA has analyzed the increases in yield and decreases in erosion that might be associated with one specific result of these practices--their effect on runoff. The analysts used the Erosion/Productivity Impact Calculator (EPIC) and varied the runoff curve numbers in the model to reflect the effects of measures that reduce runoff. The EPIC model simulates interactions of the soil-climate-plant-management factors of agricultural production. The runoff curve number is a widely used method for estimating the volume of runoff from storms. Runoff curve numbers have been estimated for specific soils, land uses, and hydrologic conditions.

3/ See chapter 9 for ground water contamination.

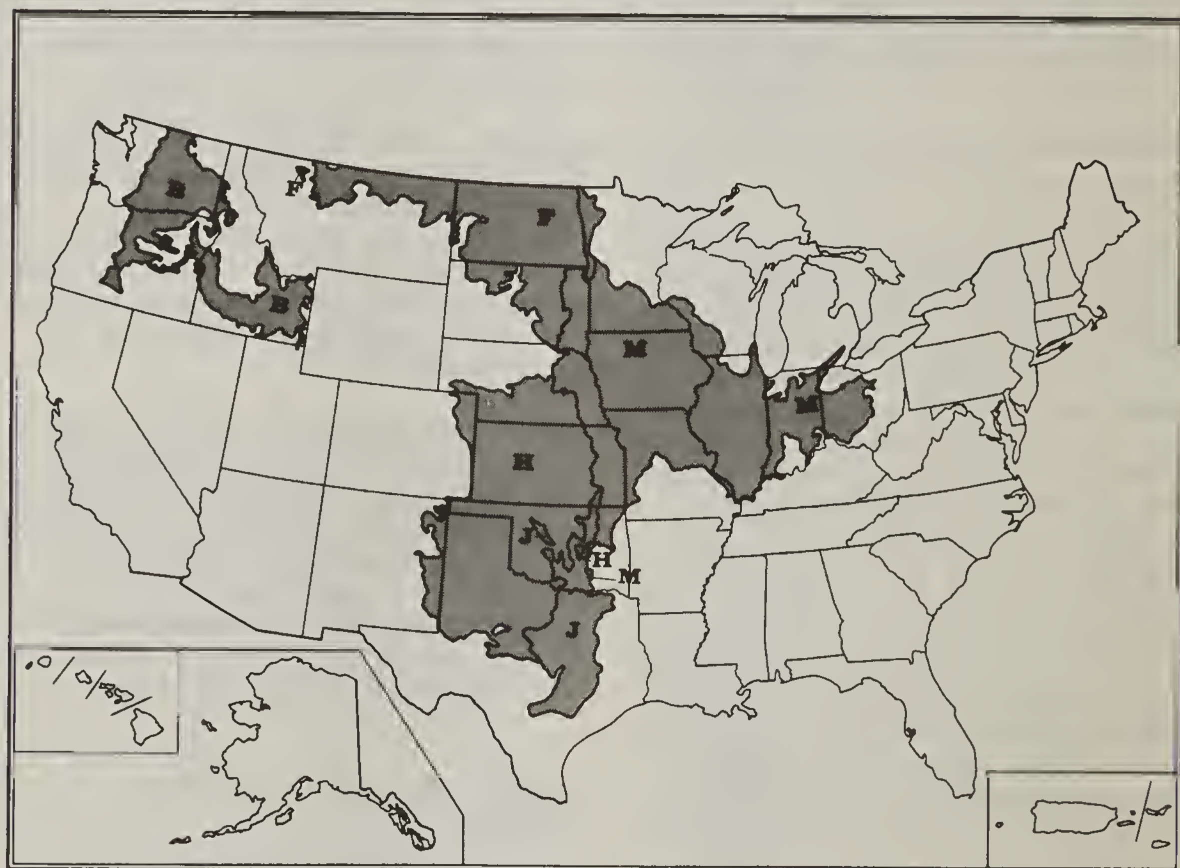
Table 23 shows the changes in yield that EPIC estimates would result from lowering the runoff curve number by specified amounts. The results shown in the table are based on representative soils in five major land resource regions. They summarize average results for each crop wherever it can be grown in the region. Results are based on average management conditions for an average soil in an average weather year. The benefits or potential hazards of changing soil infiltration rates at any specific site could differ from these averages and average results might differ in a wet or dry year.

The model estimated potential changes in the yields of winter wheat from -1.94 to +3.92 bushels per acre, changes in corn yields from +1.95 to +8.93 bushels per acre, and changes in soybean yields from +1.66 to +3.57 bushels per acre. The negative yields for winter wheat in regions J and M indicate that these regions commonly have more soil moisture than is needed for optimum growth of this early maturing crop. These changes are important and can have a significant impact on economic returns to farmers.

Table 23.--Estimated changes in yield resulting from increased infiltration, in selected land resource regions

Crop	Region	Runoff curve number reduced by 3	4	5	9
		(Bushels per acre)			
Winter wheat	B	2.14	2.85	3.07	3.92
	F	.68	.90	.99	1.34
	H	.23	.30	.38	.68
	J	-.56	-.75	-.98	-1.88
	M	-.85	-1.14	-1.30	-1.94
Corn	J	1.95	2.60	2.67	2.92
	M	4.06	5.41	6.11	8.93
Soybeans	M	1.66	2.21	2.48	3.57

Source: Erosion/Productivity Impact Calculator (EPIC).



Soil moisture management practices reduce erosion.--Farmers can reduce runoff from fields by applying soil conservation/soil moisture management practices. Table 24 shows the average reduction in runoff curve numbers associated with some conservation measures designed to reduce runoff.

Conservation measures allow less rainfall to leave a site as surface runoff. Reduced runoff means that more water infiltrates the soil, so the available moisture supply is greater. Reduced runoff also means reduced erosion. Erosion reduces the thickness of the soil; therefore, preventing erosion maintains the soil's water-holding capacity.

Table 25 shows the reductions in sheet and rill erosion that the ICE model estimates would occur if erosion control/soil moisture management practices were applied in land resource region M. Sheet and rill erosion is a serious problem in only a few areas in the other land resource regions studied; ICE does not estimate wind erosion, which is severe on some cropland in these regions.

Soil moisture management can change net returns.--Table 26 shows the estimated changes in net return to capital and management resulting from application of various measures. In most cases the ICE analysis indicates that some form of reduced tillage (conservation tillage, no-till or chiseling) would give a farmer the highest net return.

Because these practices cost considerably less than conventional methods, they result in increased net returns even in regions J and M where they decrease yields of winter wheat.

Soil moisture management on noncropland.--As important as soil moisture management practices are on cropland, they may be even more vital on nonirrigated pastureland and rangeland. For example, when overgrazing reduces the production of shallow-rooted grasses, deep-rooted brush species invade. Soil moisture can be reduced to the point that grasses will not recover without brush suppression. This consideration deserves more attention.

Related effects of nutrient management.--Improved management and adequate fertilization, which increase yields, also improve water-use efficiency. The Nation's average yields for corn, soybeans, wheat, and alfalfa have increased 15 to 18 percent in the past 10 years with little increase in water use. Using fertilizer to improve crop yields is a water management practice as well as a

Table 24.--Reduction in runoff curve number resulting from selected conservation practices

Practice	Change in watershed runoff curve number
Cropland	
Terraces	-9
Conservation tillage	-5
Mulching	-5
Residue use	-5
Grasses and legumes	-5
Diversion	-4
Contour stripcropping	-4
Contouring	-4
Chiseling and subsoiling	-3
Filter strip	-3
Stripcropping	-2
Stubble mulching	-2
Hedgerow planting	small
Grassed waterway	small
Lined waterway	small
Surface drain	small
Subsurface drain	small
Rangeland	
Mechanical range treatment	-7
Deferred grazing	-3
Brush management	-1
Fencing	small

Table 25.--Estimated sheet and rill erosion on cropland, Land Resource Region M

Conservation practice	Crop		
	Soybeans	Corn	Wheat
	(tons/acre/year)		
No treatment	25.7	24.2	5.0
Terraces	23.5	22.1	4.6
Conservation tillage	11.6	11.	13.0
No-till	8.1	9.6	2.5
Contour farming	12.9	12.1	2.5
Diversion	18.4	18.4	3.8
Contour stripcropping	10.7	10.2	1.4
Chiseling and subsoiling	11.6	11.6	3.0

Source: Interactive Conservation Evaluation System (ICE).

production practice. Adequate fertilizer helps a crop use water more efficiently because it increases the vigor of the crop. The crop therefore:

o Provides more cover during the growing period and provides more residue after harvest, which reduces runoff and increases infiltration.

o Produces more organic matter, which improves tilth and increases infiltration.

o Has greater resistance to disease and nematodes.

o Develops a larger root volume.

o Provides a more favorable habitat for soil microorganisms.

The effect on root volume is most important in dry years. The greater root volume allows the plant to extract water more completely and to a greater depth. When soil moisture is low, adding phosphorus and potassium increases the concentration gradient and speeds movement of water into the roots. Several studies have documented this effect.

Increasing soil moisture is not desirable in some cases.--Enduring practices that increase soil moisture infiltration in dry years also will do so in years when excess soil wetness is a serious problem. While this may have some benefits to ground water recharge, it also can decrease yields and net returns. Soluble nutrients or pesticides in the soil may move with the excess water through the root zone into ground water. This may pose a hazard to wells in the vicinity. Cropping practices that increase soil moisture beyond the needs of the crop in some soils can result in saline seeps (chapter 5). Because of the wide range of possible effects, including serious negative effects at some sites, expert advice should be sought for planning and implementing soil moisture management practices.

How Do Existing Institutions, Policies, and Laws Affect Water Management?

In a broad sense, most institutions, laws, and policies tend to protect vested interests more than they tend to foster changes. In this sense, existing water institutions do tend to inhibit alterations in water uses, to protect the existing patterns of water use, and to restrain new water developments. To some extent this restraint prolongs some inefficient water use practices, even where water is most in demand. Examples of limited ability to use the power of existing laws and institutions to promote water conservation can be found in states where a riparian doctrine of water law prevails as well as those where the appropriation doctrine governs. 4/

Some interstate and federal institutions, by affecting the transferability of water or its prices, may affect attitudes about water conservation. Interstate compacts, in the interests of comity, set more or less permanent apportionments of water supplies between states. Reclamation

Table 26.--Estimated changes in net return resulting from application of selected soil protection practices

Practices	Winter wheat B	Winter wheat F	Winter wheat H	Winter wheat J	Winter wheat M	Corn J	Corn M	Soybeans M
	(dollars per acre)							
Net return: (no treatment)	140.06	64.12	28.21	29.96	94.16	125.28	231.04	76.33
Change resulting from:								
Terraces	11.68	3.75	1.03	-2.01	-5.16	2.90	17.77	11.74
Conservation tillage	9.65	11.85	36.64	.57	.64	6.19	22.35	31.01
No-till	.64	7.22	29.08	6.52	9.50	12.43	7.27	53.86
Contouring	8.49	2.52	.08	-.80	-3.03	-3.59	10.76	7.27
Diversion	8.49	2.52	.08	-.80	-3.03	-3.59	10.76	7.27
Contour stripcropping	8.49	2.52	.08	-.80	-3.03	-3.59	10.76	7.27
Chiseling and subsoiling	.47	8.84	35.86	1.68	4.25	.41	9.70	20.65

Source: Interactive Conservation Evaluation System (ICE).

Project water service contracts provide subsidized water for irrigation over a long period of time and set up irrigation district organizations that tend to resist water transfers to other uses. Water reservations for Indian tribes tend to be uncertain in terms of quantity and thus create uncertainty in the water market until the amounts are established through negotiation, adjudication, or legislation. When such rights are quantified, they also tend to become permanent.

Some changes in laws, institutions, and policies that affect water use are inevitable. This trend is particularly evident in the western states where the appropriation doctrine prevails and where competition for water is most keen. This may seem to be a paradox since the appropriation doctrine is frequently viewed as giving more protection to existing water rights and established water uses than does the riparian doctrine. However, because water allocations are more clearly defined when flow, use, and storage rights are established, the effects of making changes in water use patterns can be more easily determined. This allows market forces to operate more freely than where such factors are unknown or undefinable.

Many changes can be achieved without modifying existing laws, institutions, and policies. Changes in existing water institutions, policies, or laws should be based on a detailed analysis of the physical, economic, and hydrologic characteristics of the river basin in which the changes are proposed. It is important to study the effect of proposed changes not just on water withdrawals and use patterns but also on the portion of the water that is withdrawn but not consumed under existing uses.

4/ Riparian water law and the appropriative doctrine are the two systems of water allocation that apply to flowing streams, lakes, and other surface sources. In the riparian system, the water is not owned by anyone, but the rights to use the water arise out of ownership of lands that touch the stream or lake. In the prior appropriation system, a landowner who can make beneficial use of water can obtain a permit from the State to use a given amount of water at a given time and place. The beneficial use of the water and the antiquity of the permits rather than ownership of land determine the right.

The hydramatic center pivot irrigation system being used on corn. The system covers a quarter section of land.

WATER CONSERVATION: SPECIAL PROJECTS ADDRESS CONCERNS ABOUT BOTH QUALITY AND QUANTITY OF SURFACE AND GROUND WATER

Colorado. Irrigation water for about 4.3 million acres of cropland, pasture, and hayland comes from both snowmelt and ground water. Both vary in supply; surface sources generally are not adequate. Aquifers, especially the Ogallala and in the San Luis Valley, are being depleted. Efforts to solve these problems have included a forum providing opportunities to coordinate agency activities (Colorado High Plains Technical Coordinating Committee) and demonstration of new water conservation techniques (Yuma County).

Florida. The Florida Water Resources Act of 1972 modified common law doctrines dealing with water use and created water management districts having broad statutory powers for water management. In 1980 almost 3 billion gallons per day, or 41 percent of the state's total fresh water, were used for irrigation. Funds have been targeted to the Florida Water Conservation Project, in which SCS researchers have inventoried types of irrigation systems and are studying methods of applying and managing irrigation water. Work with soils having a high water table showed they can be managed to supply water to crops by upward flux, reducing the need to pump additional fresh water.

Kansas. Continuing depletion of the Ogallala Aquifer, which supplies most of the state's irrigation water, threatens farmers in the 46 western counties. In 1983 USDA's National Conservation Program designated this as a water conservation target area and provided funds to assist farmers with water management. A team in a multi-county pilot area has been gathering data, evaluating irrigation systems, and experimenting with new techniques.

Montana. Several irrigation water conservation projects have been planned, including targeting of USDA assistance to about 620,000 acres in seven counties. Workshops and personal contacts with farmers will promote onfarm irrigation water management and automation of irrigation systems. Two small watershed projects are aimed at rehabilitating an existing irrigation system and automating onfarm irrigation systems.

North Carolina. Farmers in eastern North Carolina are installing systems for total water management to improve water quality, reduce the demand for ground water, reduce freshwater runoff on primary saline nursery areas, and increase profits. USDA's National Conservation Program funded the installation of seven demonstration projects to conserve and store water in the surficial aquifer for use in irrigation. The projects have fostered greater cooperation among government agencies, researchers, private industry, and landowners. The number of second-generation projects resulting from the demonstrations has far exceeded expectations.

Oregon. The Oregon Watershed Improvement Coalition has brought together previously opposed factions of producer, user, and environmental groups. They, and several agencies, were instrumental in formulating legislation that brought about the establishment of the Governor's Watershed Enhancement Board. This Board funds watershed improvement projects that seek to improve the functioning of watersheds primarily through management and non-structural measures.

Utah. Most water in Utah is supplied from snowmelt, which occurs during a short period in the spring and then settles to a base flow, even disappearing in some places, during the summer. Generally, high streamflow occurs when crops need water the least, and vice versa. In some places, storage reservoirs have been built to hold the high runoff until it is needed by crops. SCS is helping landowners improve irrigation methods, distribution systems, and management. As a result numerous farmers have adopted more efficient irrigation methods, and in several districts farmers have become involved in water management scheduling.

CHAPTER 7
Flood Damages Are Increasing

Flood damages, apart from deaths and other social consequences, average more than $5 billion a year. By the year 2030, damages are projected to reach $9 billion or more. Damages in upstream watersheds account for half of all flood damages, and 80 percent of upstream damages occur in rural areas.

Flood-prone lands will likely remain in agricultural use, both because of their high productive capacity and because costs of capital improvements, insurance, and related factors will discourage their conversion to other uses. Projections of future developments made for this appraisal suggest that the acreage of cropland might decrease significantly in the future. The reduction in flood-prone cropland likely would not be great, however, because a considerable portion of the reductions are projected for areas where not much of the cropland is flood-prone.

Agricultural damages are expected to increase in the future because cropland is being cropped more intensively, requiring larger investments. Damages to cropland and pasture, however, will not increase as rapidly as damages in urban areas and damages to land in other rural uses.

Slightly more than 195 million acres of nonfederal rural land are flood-prone (fig. 47). Flood-prone areas are the lowland and relatively flat areas that adjoin inland and coastal waters and are subject to a 1-percent or greater chance of being flooded in any given year. Flood-prone land includes alluvial fans, plains, or other lands adjoining rivers, streams, water courses, bays, and lakes, but does not include temporarily ponded areas in uplands.

Two-thirds of total damage caused by floods occurs in rural areas. In upstream watersheds, where USDA provides assistance in preventing damages, over 80 percent of flood damage occurs in rural areas. About 31 percent of nonfederal rural flood-prone land is used as cropland and 28 percent is forest land (fig. 48).

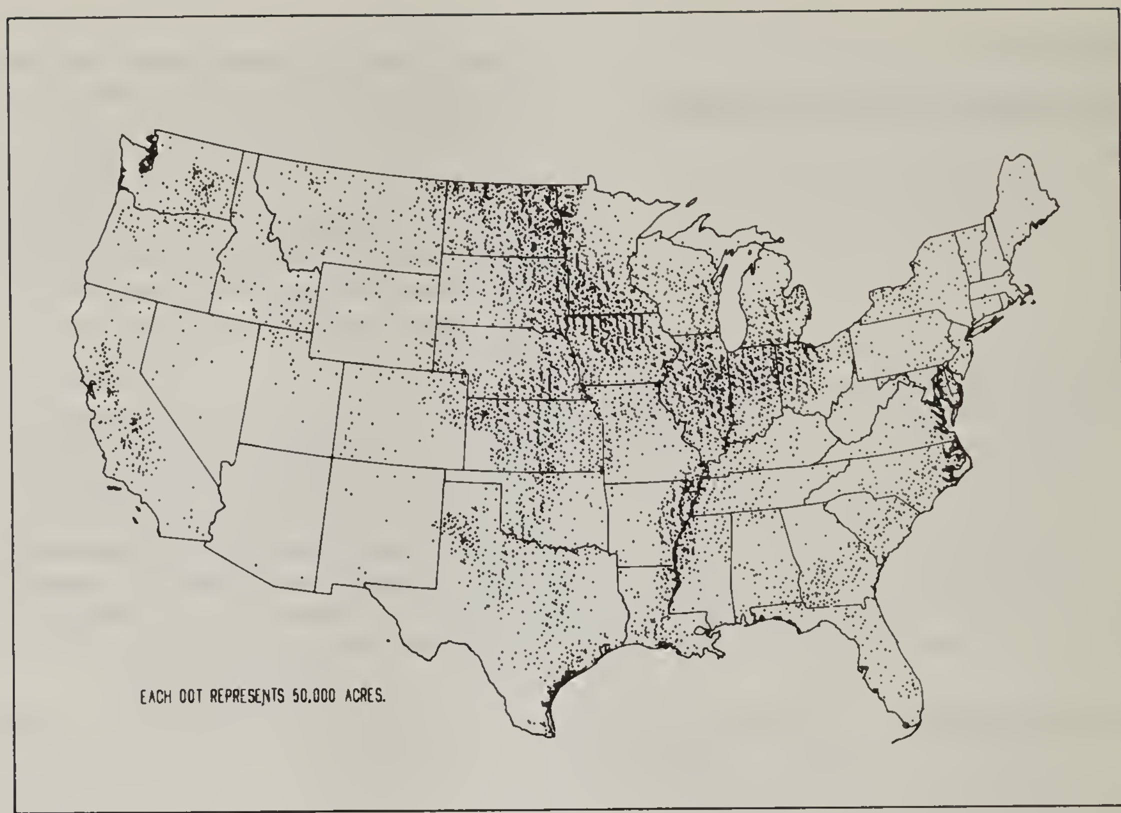


Figure 47.--Flood-prone rural land (1982 NRI). Each dot = 50,000 acres. The dot pattern is computer generated and does not show exact sites within a state. For state data, see appendix table 43.

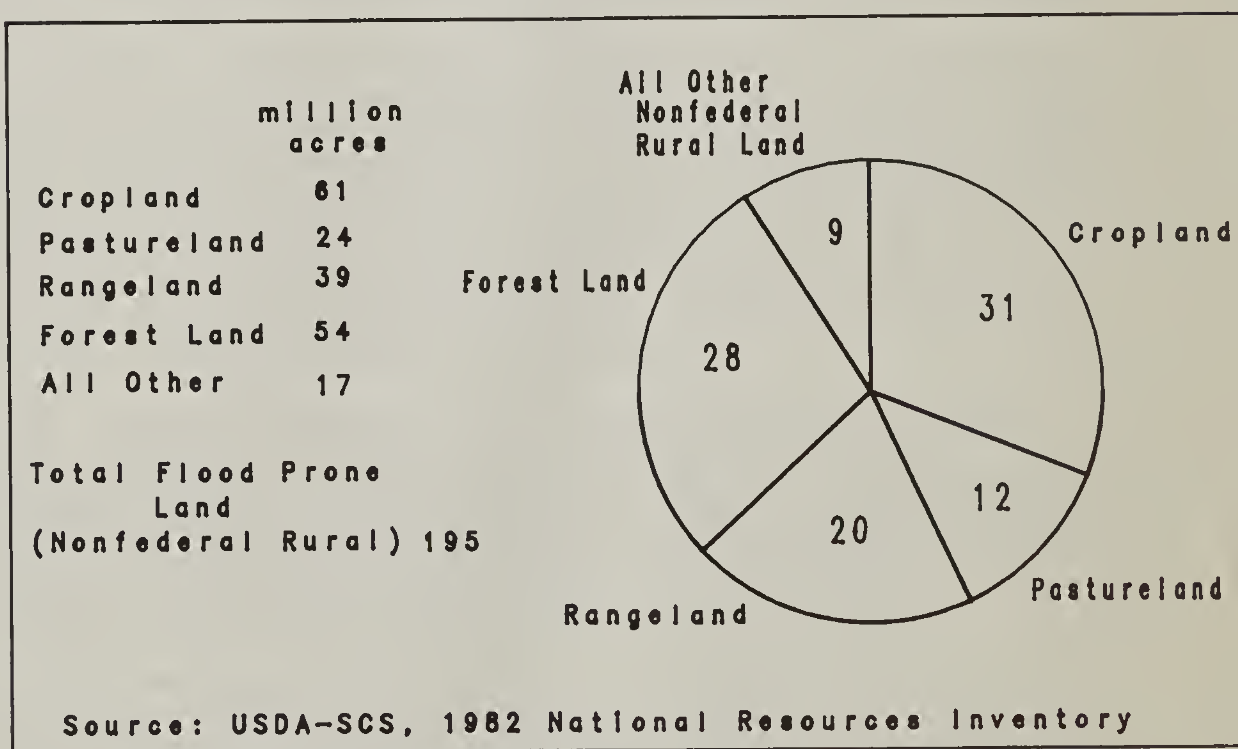


Figure 48.--Use of flood-prone rural land (1982 NRI).

How Severe Are the Damages?

Floods are among the most significant natural phenomena in the United States in terms of loss of life and property. Between 1925 and 1984, a total of 6,172 people died in floods. During the last two decades, flooding has caused an average of 151 fatalities annually (fig. 49).

About 20,000 of the 34,000 communities in the United States have some flood hazard areas. 1/ In 1975, flood-prone lands were estimated to contain at least 6.4 million structures.

Storm events and subsequent flood damages vary widely from year to year, but available data on costs show a steady upward trend unrelated to changes in dollar value. No unified data base exists for recording flood damage information, and data sources vary widely in their estimates, primarily because different organizations use different criteria to define property damages.

The National Oceanographic and Atmospheric Administration/ National Weather Service (NOAA/NWS) estimates average annual flood damage between 1940 and 1984 to be $1.5 billion in 1980 dollars. A regression analysis of these data showed damages rising by $30.3 million per year (fig. 49).

In addition to the threat of loss of life and property, floods cause other damages to people living in flood plains:

- Health hazards, such as insect breeding pools, sewage overflows, and chronic wet conditions that are particularly hazardous to the elderly and to children;
- Significant risk and inconvenience associated with damage to roads and bridges;
- Disruption of necessary services such as police and fire protection and use of emergency equipment;
- Pollution of drinking water;
- Interruption of utilities.

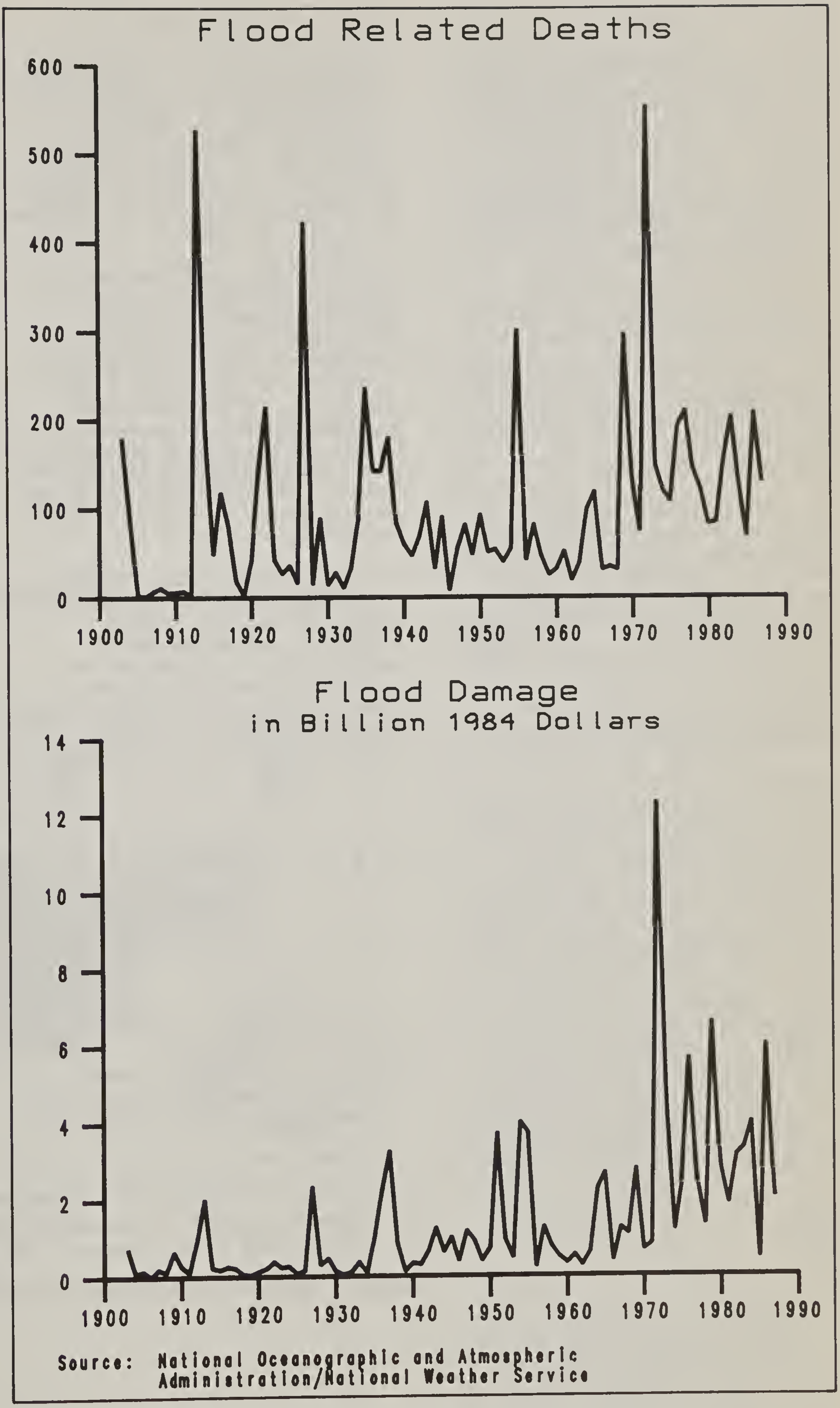


Figure 49.--Flood related deaths annually and annual flood damage, 1903-84.

1/ Federal Emergency Management Agency. 1986. A unified national program for floodplain management.

Upstream Flooding

The Water Resources Council estimated damages for "1975" to be $5 billion (updated to 1980 dollars). This estimate is higher than the NOAA/NWS because the NOAA/NWS probably does not include many of the agricultural damages caused by minor storms; minor storms generally account for 70 percent of agricultural damages. 2/

The Council projected flood damages to increase to $7 billion by the year 2000 (1980 dollars). This rate of increase would result in damages of $9 billion by 2030. Projecting the trend for the NOAA/NWS data, damages would be $3.5 billion in 2000 and $4.7 billion in 2030.

Table 27 shows the Council's estimates for upstream and downstream areas, updated to 1980 dollars. "Upstream" generally means main and tributary areas with no more than 400 square miles of drainage. There is no indication that the distribution between upstream and downstream areas or between types of damages has changed significantly since the Council's estimates were made.

The Council projected that upstream damages would increase from 47 percent of the total in "1975" to 50 percent in 2000. Upstream flood damages will continue to increase as the real values of property in flood plain areas increase. Even though many communities have voiced concern over the development of flood-prone lands and the number of regulations governing the use of flood plains has grown, large investments will continue to be made in flood hazard areas. Agricultural damages are expected to continue to increase because of the large acreage of flood-prone land used as cropland. Shifts in crop production to flood-prone lands will add to this upward trend.

2/ U.S. Water Resources Council. 1978. The Nation's water resources, 1975-2000. Second national water assessment, vol. 2, water quantity, quality, and related land considerations.

Damages to Agricultural Land

Two-thirds of total flood damages occur in rural areas (table 27). The Water Resources Council projected rural damages to increase more slowly than urban damages but to continue to make up the majority of total damages: 63 percent by the year 2000 versus 66 percent in "1975."

About 14 percent of cropland (fig. 50) and 18 percent of pastureland are flood-prone. Flood-prone lands are highly productive, supplying as much as 20 percent of the Nation's crop production. These lands are expected to stay in production because of their high productivity. On cropland, flooding that occurs in a period other than the growing season is generally not a limitation.

On irrigated cropland, flooding can damage expensive irrigation facilities such as ditches, pipelines, and sprinklers. Agricultural flood damages are expected to increase because existing cropland is being cropped more intensively, requiring greater investments.

Flood damages and erosion are related. The sediment eroded from agricultural and other land by excessive runoff can increase the frequency and depth of flooding, primarily by aggradation of streambeds. Sediment causes property damage when it is deposited by flood waters.

Sediment deposited by flood waters can cause two types of damage on cropland. One is the long-term loss in yield associated with the deposition of relatively infertile material on good agricultural land. The value of this loss has not been estimated.

The other loss is damage to the current crop that occurs when sediment buries growing crops or covers plants with a thin film of sediment that interferes with photosynthesis and respiration. The amount of this damage ranges from $5 to $40 per acre of flooded cropland, averaging about $20 per acre. Data from SCS watershed protection projects and river basin studies indicates that about 9.1 million acres of flood-prone cropland are damaged by sediment each year. Nationwide, the loss of production caused by sediment deposition ranges from $150 to $500 million annually (table 28).

Table 27.--Flood damages in "1975" 1/ normalized water year

	Upstream	Downstream	Total	
	(millions of 1980 dollars)			%
Urban and built-up land	434	1,218	1,652	33
Agricultural land	1,632	807	2,439	49
Other (rural utilities, roads, railways, homesteads, forests, grasslands, refuges, parks, etc.)	441	485	926	18
Total	2,507	2,510	5,017	100

1/ "1975" represents a normalized year based on average water use in 1975. Data do not represent actual water use in that year.

Source: Second National Water Assessment.

Table 28.--Damage to growing crops

Farming region	Flood-prone cropland: Thousand acres	Flood-prone cropland: Percent of region's cropland	Annual damages 1/ Millions of 1984 dollars
Northeast	963	6	2.9
Lake States	3,308	8	9.9
Corn Belt	14,216	15	42.7
Northern Plains	10,452	11	31.3
Appalachian	5,344	24	16.0
Southeast	2,444	13	7.3
Delta States	9,877	45	29.6
Southern Plains	5,249	12	15.8
Mountain	3,925	9	11.8
Pacific	4,821	21	19.5
Total	60,599	14	181.6

1/ Assumes 15 percent of cropped flood-prone acres receive annual sediment damage of $20 per acre.

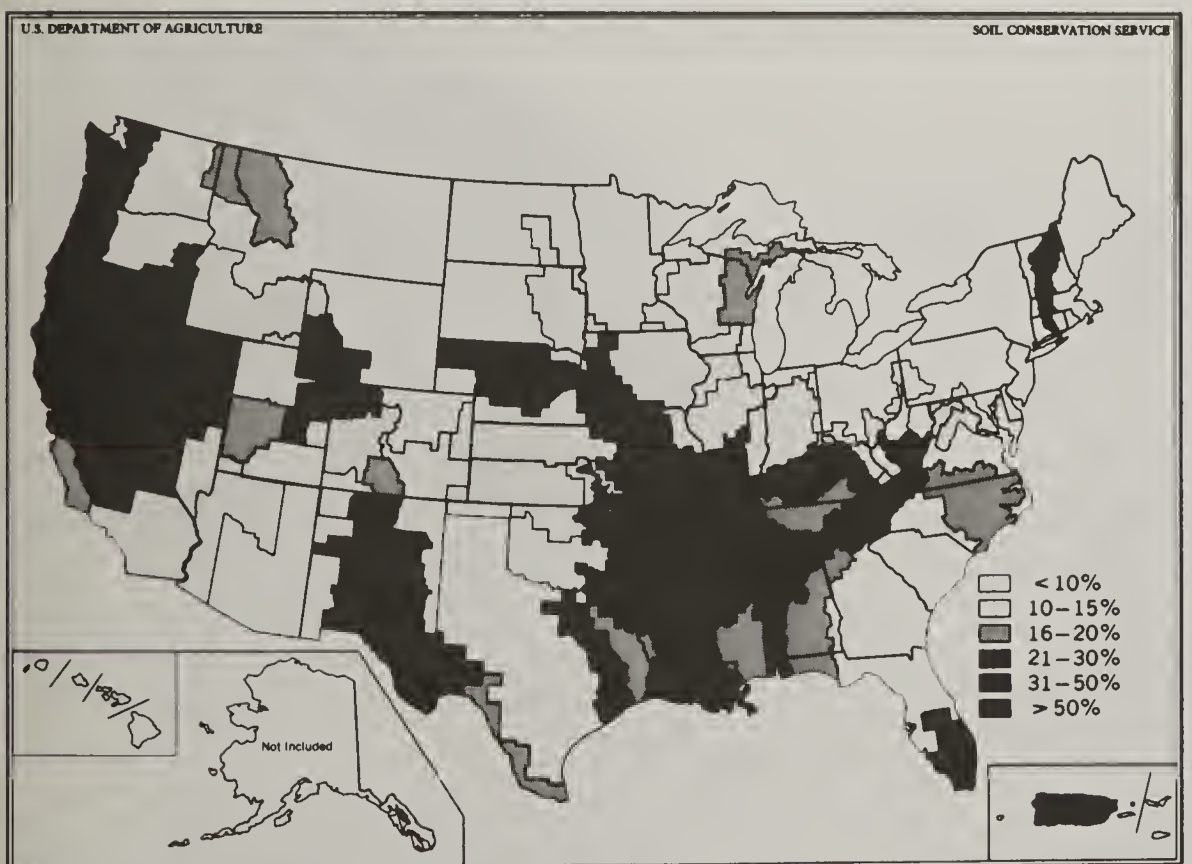


Figure 50.--Percentage of cropland subject to flooding, by aggregated subarea.

Limiting Flood Damages: What Can Be Done?

There are three general approaches to relieving flood damages. None of the three is sufficient alone; flood-plain management that combines at least two of them generally provides the greatest net benefit.

The first approach seeks to modify the impact of flooding on individuals and communities. It eases suffering and hardship and provides economic relief by means of flood emergency measures, post-flood recovery measures, flood insurance, and tax adjustments.

The second approach modifies susceptibility to the damage and disruption caused by flooding; that is, it seeks to protect life and property. It includes information programs to make the public aware of flood hazards, flood plain regulations and development and redevelopment policies, disaster preparedness and assistance, and response planning, flood proofing, snowpack forecasting, and flood forecasting and warning systems and emergency plans.

The third approach modifies flooding by containing or redirecting floodwaters before they overflow. It comprises structural measures--such as dams, dikes, levees, floodwalls, channel alterations, high flow diversions and spillways, and onsite detention measures--and also land treatment measures designed to increase infiltration and reduce runoff. The Water Resources Council estimated that flood losses could be reduced by 20 percent if all economically feasible flood control structures were built. Economic conditions have reduced the number of flood-control projects funded. The federal investment in water resources projects is less than 0.3 percent of the total federal budget.

The Flood Control Act of 1944 and the Watershed Protection and Flood Prevention Act (Public Law 83-566, Stat. 666) authorize USDA to work with local people and organizations in solving flood problems. The programs developed under the Watershed Protection Act are unique among federal water programs in being federally assisted, not federally directed.

All actions pertaining to them must be initiated by local people, and decisions as to the scope of any project are made locally. The federal government's commitment to cooperate on any proposed project is based on current policy, approved guidelines, and Congressional constraints.

The economic benefits and effects of the watershed program, which has existed for 30 years, are documented in an evaluation required by the Resources Conservation Act. Benefits to rural communities exceeded planned benefits by nearly 200 percent, and sediment damage reduction was more than 300 percent greater than planned.

The shifts from planned benefits were primarily away from the agricultural sector and toward urban areas.

The 60 sample projects completed by 1978 were analyzed in both the preproject (project plan) and post-project (1984) stages for the number of buildings that would be susceptible to flood damage with and without project measures in the event of a 100-year frequency flood. A "100 year frequency flood" has one chance in 100 of being equalled or exceeded in any one-year period. The preproject and post-project estimates indicate that Public Law 566 projects reduced by 95 percent the number of buildings susceptible to flood damage. The data for fiscal year 1984 showed that because of suburban expansion the number of buildings susceptible to flooding is increasing. The greatest increase was for residences.

The Soil Conservation Service designed and supervised reconstruction of the spillway at Southfork Site 17 lake and dam in Pendleton County, West Virginia, after severe flooding destroyed the emergency spillway in 1985.

CHAPTER 8
Atmospheric Deposition Is Causing Popular Concern

Studies have demonstrated that plants are injured and crop yields are reduced by the presence of above-normal levels of ozone in the surrounding air. Tests have not demonstrated damage to annual crops by "acid rain."

There is a growing popular concern that atmospheric pollution and the resulting deposition may be damaging aquatic ecosystems and injuring forests in the United States. Water bodies and soils in some areas are more acidic because of acid rain.

The Department of Agriculture is a leading participant in several programs designed to identify and monitor the effects of this atmospheric deposition on crops, forests, soils, and surface waters.

The term "atmospheric pollution" means the release into the earth's atmosphere of gaseous pollutants (ozone, sulfur dioxide, and oxides of nitrogen), atmospheric particulates (dust, smoke), and acidifying chemicals. Many of these particles and gases eventually are deposited on the earth's surface in either wet precipitates (rainfall, aerosols, fog) or dry deposition.

Many chemicals, released into the atmosphere, affect sensitive biotic species in the vicinity of the source. The various components of atmospheric deposition directly affect terrestrial ecosystems, and the components themselves can change as they cycle through the ecosystem. Deposited chemicals may be taken directly into plants by the foliage, altered by passing through plant canopies, taken up by plant roots from the soil solution, utilized or modified by soil organisms, altered by soil chemical reactions, and discharged into lakes and streams. They can cause changes in plant health and vigor, changes in soil productivity, and acidification or other chemical changes in surface waters. On the other hand, they may contain nutrients that can enhance plant growth. Many terrestrial ecosystems can buffer, or neutralize, acid deposition.

There is concern in the United States that acidic deposition, or acid rain, may have substantial adverse impacts on plant growth (crop and forest production) and on water quality. There is also a more general concern that deposition of atmospheric pollutants--including photooxidants such as ozone, oxides of nitrogen and sulfur, other gases, and metals--is "bad for the environment." Unexplained growth reductions are occurring in some U.S. forests, and acidification of some streams and lakes has been documented. Although the changes in forest condition could be due to factors other than air pollution, the widespread forest decline in central Europe, generally regarded as caused by atmospheric pollutants, has helped focus attention on the potential for a similar problem in the United States. Research to date has shown little effect of acidic rain on crops, but the adverse effects of photooxidants and acidifying gases on 70 crops are well documented.

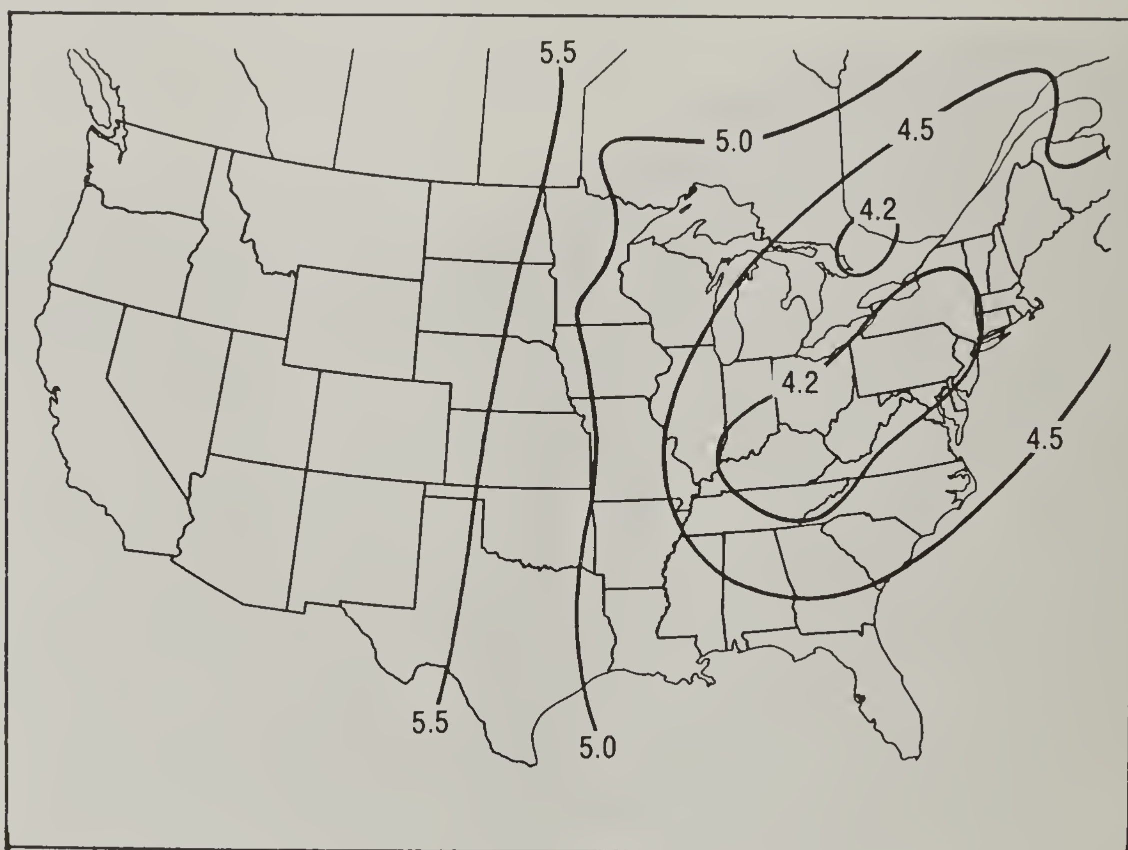


Figure 51.--Precipitation acidity--annual average pH for 1980. Adapted from: Acid rain and transported air pollutants. 1984. Office of Technology Assessment.

Atmospheric deposition data are being collected to provide information on geographic patterns and time trends. Current levels of precipitation acidity, the geographic pattern of sulfate deposited in precipitation, and the pattern of ammonium-nitrogen and nitrate-nitrogen in precipitation are shown in figures 51 and 52. In figure 51, the increase in acidity toward the north and east is not a simple linear progression: precipitation at pH 4.2 is about 20 times more acidic than at pH 5.5. The highest concentrations of deposited acidic pollutants center on the eastern Great Lakes region and the Ohio River valley.

Data collected before 1950 are of relatively little value for time-trend comparison. Some data of the 1950's can be qualitatively compared with data for 1978 to the present collected under the National Atmospheric Deposition Program (NADP). However, this comparison, which seems to show an increase in acidity, has been debated at length. Experts who examined trends for all the ions found that ions with soil sources (e.g. calcium and magnesium) decreased dramatically over the period; thus the apparent decrease in pH could result not from the presence of more acidic pollution but from the decrease in basic particles. The higher calcium and magnesium concentrations in the precipitation of the 1950's probably were due to one or both of two factors: the drought of the 1950's, and inadequate sampling methods.

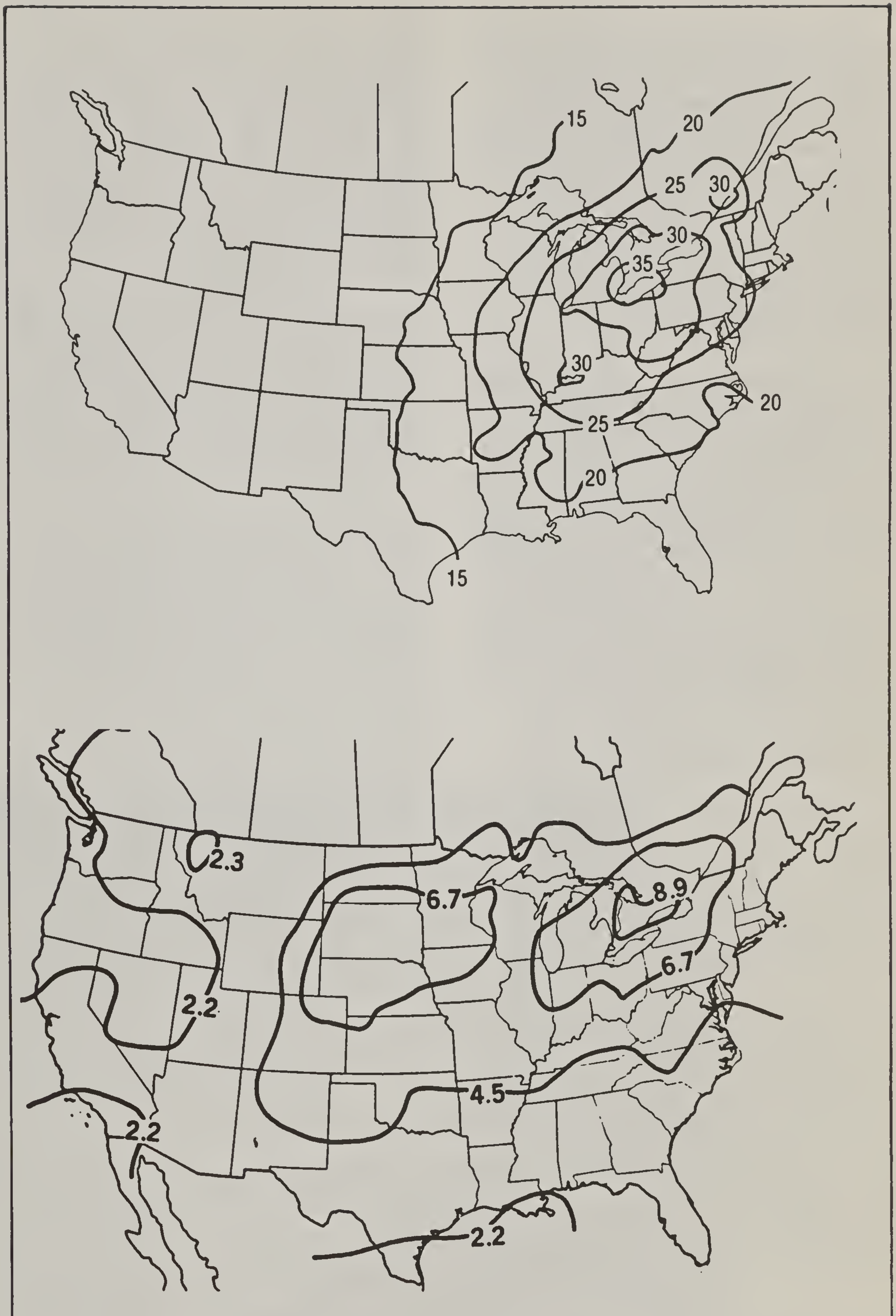


Figure 52.--Deposition of sulfate (top) and of ammonium-nitrogen and nitrate-nitrogen (bottom) in precipitation. Sulfate map shows 5-year annual composite for 1980-84 in kilograms per hectare; in pounds per acre they would be approximately 11 percent less. Nitrogen map shows deposition in 1981 in pounds per acre.

What Are the Known Effects of Ozone and Acidic Deposition on Crops, Forests, Soils, and Surface Waters?

Crops

Ozone accumulations in the lower atmosphere are known to reduce yields of many crops and other plants. Vegetation damage from constituents of photochemical air pollution (ozone and associated oxidants) was first identified in the mid-1940's by agricultural scientists in the Los Angeles basin. 1/ Ozone, however, has not been demonstrated to have harmful effects on soil or water resources.

Crop productivity is significantly affected by ozone on a broad regional basis and--especially in the vicinity of point sources--by sulfur dioxide (SO_2). The National Crop Loss Assessment Network (NCLAN), an Environmental Protection Agency (EPA) program, has studied the effects of ozone on selected crop species. NCLAN experiments estimated yield losses, for crops exposed to ozone at concentrations of about 50 parts per billion (ppb) in ambient air, as follows: soybeans, 9 to 18 percent yield loss compared to yields in clean air (natural background ozone of about 25 ppb); corn, less than 1 to 3 percent yield loss; wheat, 6 to 16 percent; cotton, 3 to 20 percent; peanuts, 13 percent; lettuce, 22 percent; and kidney beans, 3 percent. When ozone concentrations around those crops are artificially increased above 50 ppb, yield losses are greater.

Data from NCLAN field experiments were used to develop dose-response functions that express the changes in yield of corn, soybeans, wheat, cotton, grain sorghum, barley, and hay resulting from changes in ozone. These functions were used in a large-scale model of the U.S. agricultural sector to evaluate the effects of hypothetical reduction or increase in ozone levels over crop regions. 2/ The model also calculates changes in the livestock economy as the effects of changes in crop prices caused by ozone work their way through the agricultural system. The EPA study concludes that reducing ozone levels 25 percent would result in a benefit to society of $1.6 to $1.9 billion, with both farmers and consumers sharing in the benefit.

Conversely, a 25-percent increase in ozone levels would result in a cost or loss to society of $1.9 to $2.3 billion, with both farmers and consumers sharing in this loss. Comparable studies by other economists reach generally similar conclusions.

Experiments with simulated acid rain conducted for the National Acid Precipitation Assessment Program (NAPAP) and the National Atmospheric Deposition Program (NADP) have shown little or no resulting reduction in crop yields. Test plots showed no yield reductions for corn and wheat; yield was reduced for only one soybean variety. Controlled experiments are still under way on clover, timothy, tomatoes, potatoes, cotton, tobacco, alfalfa, and peanuts. In preliminary results, yields of these crops show no significant reduction resulting from simulated acid rain. Possible effects on other crops are under investigation.

Forests

Ozone is causing visible injury to ponderosa and Jeffrey pine in California and to some eastern white pine in the East. There is evidence that this problem is increasing. Studies suggest that ozone at ambient levels probably reduces forest growth across most of the country.

Unexplained growth loss is occurring in red spruce in New England (fig. 53). The same condition afflicts spruce along the Appalachians, pitch pine in New Jersey, and some loblolly pine in the Piedmont region of the Southeast. Other symptoms of decline have been documented, such as early mortality and loss of foliage (fig. 55). There is currently no conclusive scientific evidence linking acidic deposition to these problems. Circumstantial evidence suggests that acidic deposition plays a role in the spruce decline, because deposition rates are greater at the high elevations where spruce is dominant. It is not yet clear, however, whether the damage is due to the susceptibility of red spruce as a species or of the high-altitude coniferous forest as an environment, with its severe climate and thin soils already leached of nutrients, or to the interaction of these and other factors. One factor is heavy-metal deposition: above-normal amounts of lead, cadmium, zinc, and copper have been found in forest soils and litter on high, windward slopes all along the Appalachians. Long-term effects of the removal of nutrient cations (especially calcium and magnesium) from forest soil by acidic deposition have not been determined.

In numerous laboratory and greenhouse studies, tree seedlings have been exposed to simulated acid rain, alone or in combination with other air pollutants. Response varied dramatically with

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1/ Middleton, J.T., J.B. Kendrick, Jr., and H.W. Schwalm. 1950. Injury to herbaceous plants by smog or air pollution. Plant Dis. Report, 34:245-521.

2/ Adam, R.M., S.A. Hamilton, and B. McCarl. 1984. The economic effects of ozone on agriculture. EPA Report 600/3/84/090. U.S. Environmental Protection Agency, Office of Research and Development, Corvallis Environmental Research Laboratory, Corvallis, Oregon.

soil type. Many of the early studies used organic soil with both a high pH (inhibiting the growth of conifer seedlings) and a large buffering capacity. Thus the seedlings grew better when the applied acidic rain lowered soil pH to a salutary level. The effect of simulated acid rain on loblolly and shortleaf pine was to limit root length; ozone exposure reduced shoot growth in those two species. Red spruce growth was stimulated by combinations of simulated acid rain and mists. White oak showed a reduction in the width of growth rings, but an increase in height. Some initial growth increases could be due to the nitrate in acidic deposition. One study showed a reduction in the incidence and vigor of ectomycorrhizae on loblolly pine roots.

Surface Waters

Watershed-level research aimed at determining the effects of acidic deposition on surface waters and soil processes has been active much longer than analogous research on forests. There is sound evidence that acids in rainfall contribute to acidification of some lakes and streams in certain areas and that these acids, falling on soil or bedrock, mobilize aluminum and other heavy metals, which in turn can injure the aquatic environment. In some areas, fish populations and other aquatic life are being adversely affected by acidification. For example, about 180 lakes in the Adirondacks were reported, in studies dating from the mid-1970's, to have become acidified and to lack fish. These lakes cover roughly 18,000 acres, about 6 percent of the total lake surface area in the Adirondacks. Soil alkalinity in that region is naturally low, however, and lake acidification can be a natural process there even in the absence of acid rainfall. The degree to which acid rain has caused acidification of those lakes has not been established, although the evidence points to deposition acidity as an important influence.

Stream acidity does not seem to be increasing in the Southeast as it has in some northeastern systems. Studies in the central Appalachians indicate that undisturbed watersheds are effective in neutralizing acids received in precipitation. Nevertheless, the resulting accumulation of sulfate and net loss of cations could lead to acidification and nutrient depletion in the future. A recent finding shows the buffering capacity of some New England soils is in their mineral, not their organic layers.

Because liming affected waters temporarily reduces acidity, the cost of liming can be an

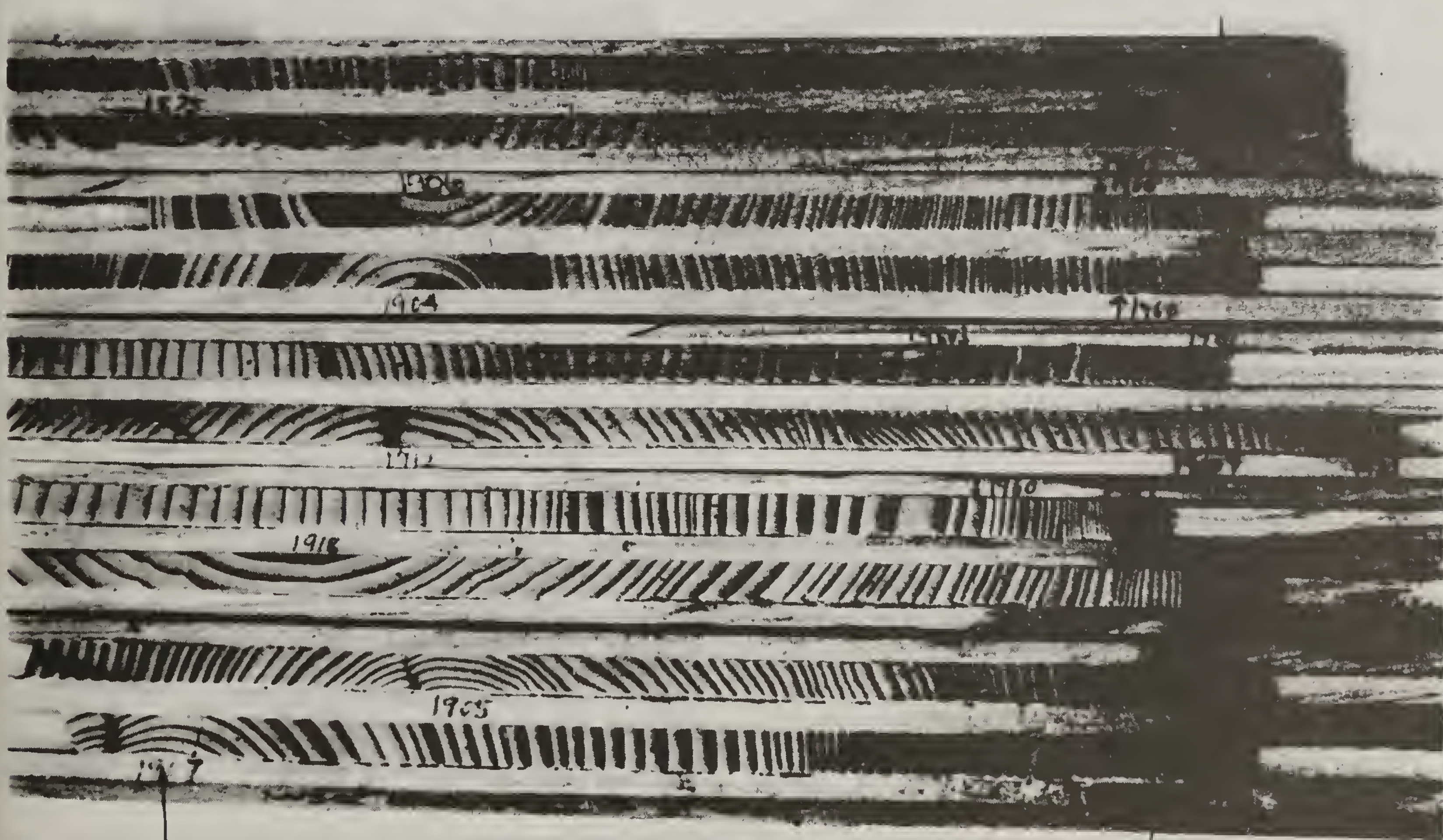


Figure 53.--Tree ring cores from red spruce at Mount Washington, New Hampshire, showing a decline in growth after 1960.

approximation of the dollar value of the damage to an aquatic environment. However, liming may not fully counteract aquatic damage if heavy metal toxicity is not adequately controlled or if fish spawning grounds in streams are not limed. In addition, liming needs to be repeated every few years. Massachusetts and New York established small-scale, experimental liming programs in 1957 and 1959 respectively. In New York the costs of treating ponds and lakes with crushed limestone have ranged from $90 to $300 per acre, depending largely on whether the site is accessible by road or boat or only by aircraft.

A recent study 3/ estimated that a 5-year program for liming all the known acidified lakes in the Adirondacks would cost from $2 to $4 million per year, depending on the desired buffering level. This estimate does not include the costs of restocking fish or of monitoring chemical and biological changes in treated waters.

Soils

Several soil studies have addressed the effects of acidic deposition on chemical leaching and metal mobility. Soils in Maine, Tennessee, South Carolina, and North Carolina showed an increase of 50 to 100 percent in ion movement under treatments with simulated acidic deposition. Some sites have shown a net gain in calcium or potassium from deposition, so increased leaching may not necessarily lead to net losses of all nutrient cations. Under extremely acid conditions, soils release aluminum, which is toxic to plants; however, the release of aluminum depends not only on soil pH but also on the soil's organic matter content, cation exchange capacity, and mineralogy. Simulated acid rain at pH 4.0 seems to have little effect on aluminum mobility, but at pH 3.0 more aluminum is released. Cropland soils are generally not thought to be at risk because agricultural liming normally adds bases at rates far surpassing deposited acids.

Both nitrogen and sulfur are nutrients utilized by plants in active growth. For unmanaged forests, atmospheric deposition is often a major source of available nitrogen. Where nitrogen and (less commonly) sulfur are in short supply, their deposition in dilute acid form may take on economic value. For example, many soils in the Southeast are deficient in sulfur. One experiment using tracer methods found that as much as 50 percent of the sulfur used by some crops in the Tennessee Valley states came from atmospheric deposition. The annual value of atmospheric sulfur in that area was then (1979) estimated to be about $0.40 per acre on the basis of the mechanically applied sulfur it replaced.

Since the average amount of ammonium-nitrogen plus nitrate-nitrogen deposited from the atmosphere is about 4½ pounds per acre per year, that amount would be worth about $1.04 per acre at an average cost of $0.23 per pound of purchased nitrogen (1981). This estimate does not consider volatility of the nitrogen, loss by runoff, season of deposition, or site of deposition, such as harvested cropland, grassland, or forest.

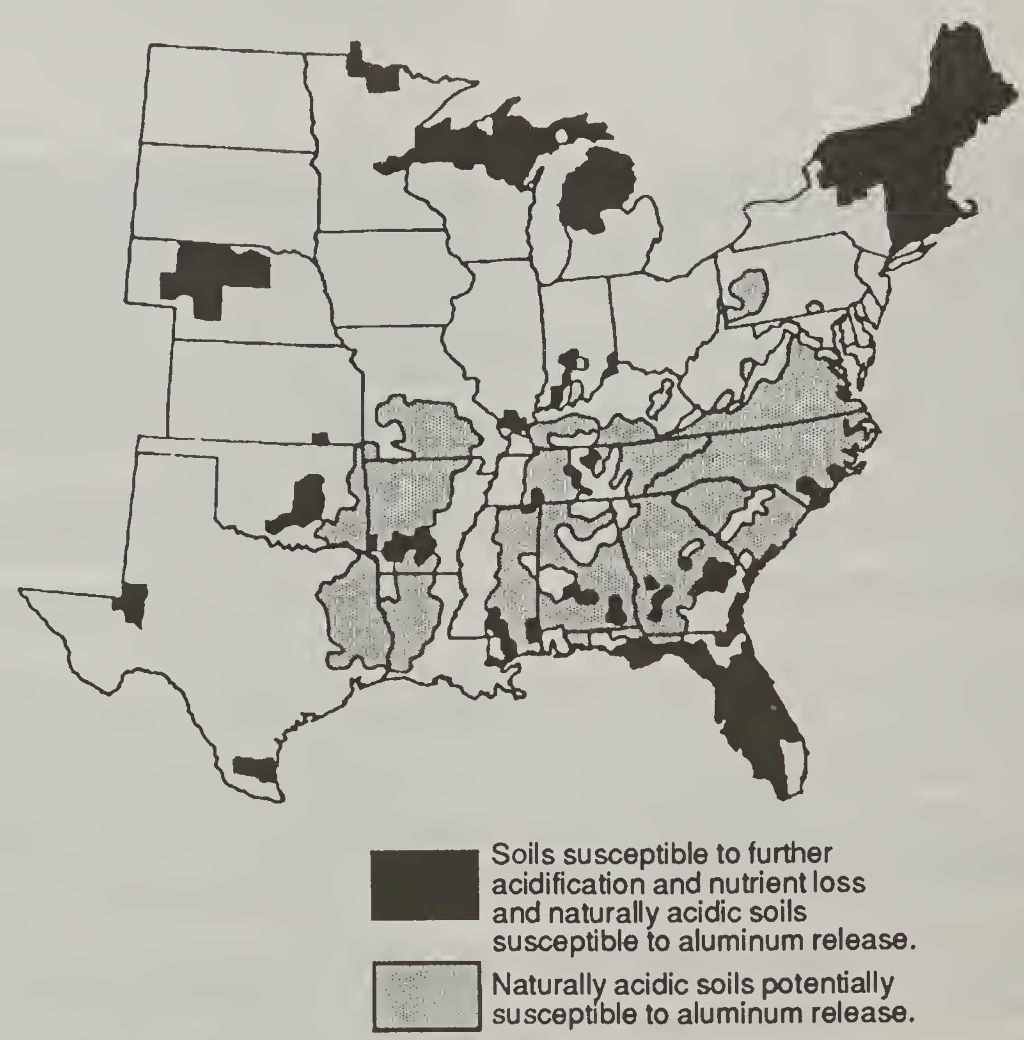


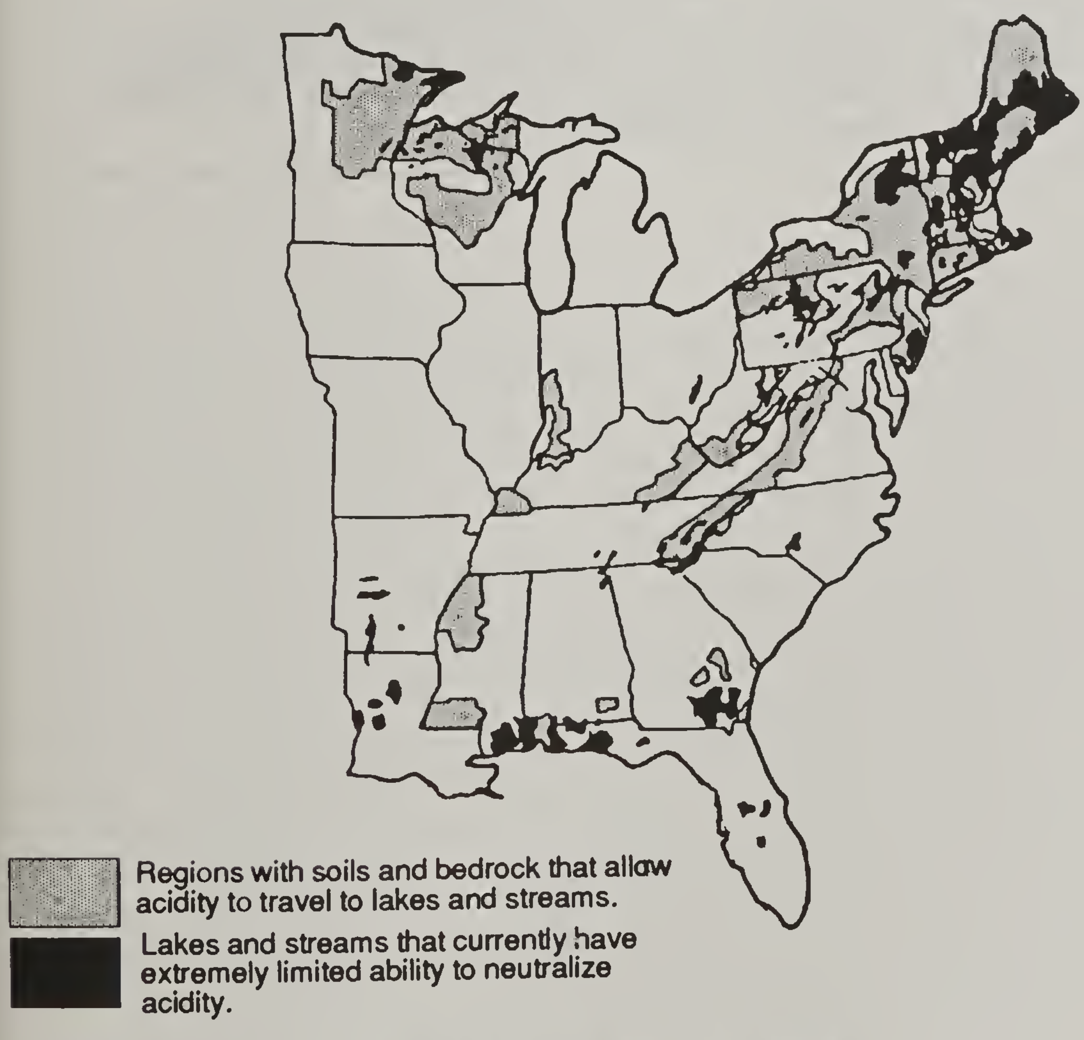
Figure 54.--Areas where soils and surface waters are sensitive to acidic deposition.

3/ Menz, F.C., and C.T. Driscoll. 1983. An estimate of the costs of liming to neutralize acidic Adirondack surface waters. Contribution #13 of the Upstate Freshwater Institute, New York.

What Is USDA's Role in Studying Atmospheric Deposition?

In 1977, the Department of Agriculture in cooperation with the state agricultural experiment stations organized the National Atmospheric Deposition Program (NADP). Known then as Regional Project NC-141, the project was to design a national atmospheric deposition monitoring network and to conduct research on possible effects of atmospheric deposition on agricultural crops and soils, forests, surface waters, and materials. Additional cooperators on the project include the state schools of forestry, other federal agencies, industry, and scientists from other countries, notably Canada. Collection of wet-deposition samples began in 1978. The NADP network has grown to some 180 sites, including 150 National Trends Network (NTN) sites that were mandated in the 1980 Acid Precipitation Act.

The 1980 Acid Precipitation Act also authorizes the federal National Acid Precipitation Assessment Program (NAPAP), a 10-year program to provide information necessary for eventual decisions on pollutant emission controls. The Department of Agriculture has the lead responsibility in studies on the effects of atmospheric deposition on crops, forests, soils, and watersheds. The research is being done at universities, national laboratories, and experiment stations. The Department also has a formal agreement with the Federal Republic of Germany for a scientific exchange program on atmospheric deposition.



SOURCES: Office of Technology Assessment. Composite map from the Institute of Ecology, "Regional Assessment of Aquatic Resources at Risk from Acid Deposition," OTA contractor report, 1982; and J. Omernik, "Total Alkalinity of Surface Water," draft map prepared to the U.S. Environmental Protection Agency, 1983.

The Department of Agriculture is a key participant in the National Crop Loss Assessment Network (NCLAN), which was established in 1980 under the leadership of EPA. Activities of this network have been undertaken by scientists from EPA, USDA, several major universities, and the Argonne, Brookhaven, and Lawrence Livermore National Laboratories. NCLAN objectives are: to define the relationships between yields of major agricultural crops and doses of ozone, sulfur dioxide and oxides of nitrogen, and their mixtures, as required to satisfy the needs of economic assessment and to support the development of national standards for ambient air quality; to assess national primary economic consequences resulting from exposure of major crops to air pollutants; and to gain understanding of the mechanisms that determine crop response to pollutant exposures.

The Forest Service and EPA, together with the forest industry, have begun a Forest Response Research Program to determine the causes of forest decline and to assess the effects of acidic deposition and associated oxidants on major forest types. Research cooperatives are now at work on eastern spruce-fir forests and southern commercial forests (primarily pines).

EPA has conducted a National Surface Water Survey, based on a statistical sample of lakes and stream reaches in the East and lakes in the upper Midwest, which will be used to estimate the number of acidic lakes and streams in those regions. This survey also formed part of the groundwork for the National Direct/Delayed Response Project, in which SCS scientists have furnished data on the soils and vegetation in selected watersheds to EPA's system modelers. The project will classify the watersheds according to their susceptibility or resistance to the effects of acidic deposition.

ACID PRECIPITATION IS A RECOGNIZED PROBLEM IN THE NORTHEAST

Massachusetts. State law enacted in 1985 calls for the establishment of an emissions reduction program for the state if no regional or federal plan is adopted by the end of 1987. The law funds 20 research projects on the effects of acid rain on air and water quality, forests, watershed areas, and agricultural resources. resources.

New Hampshire. Acid rain appears to pose a significant threat to the state's natural environment. Concern is increasing about the effects of acid rain on the forests, soils, and water of the state. The problem exists statewide but appears most critical at the highest elevations. SCS soil scientists helped the Environmental Protection Agency conduct the 1985 survey of the effects of acid deposition on soils.

New York. Acid atmospheric deposition is a grave concern for the 6-million-acre Adirondack Region, one of the most severely affected areas in the world. Damage to some 550 lakes in the Adirondacks is considered catastrophic. About 2 million acres in the Catskills also are affected, though to a lesser extent. Various tree species in these areas are undergoing rapid deterioration. New York was a primary participant in the Environmental Protection Agency's pilot study for the National Direct/Delayed Response Acidic Deposition Project. This pilot study developed techniques and protocols for the multimillion-dollar national project.

Vermont. Because Vermont is downwind of major midwestern industrial centers, highly acid precipitation routinely falls throughout the state. Lakes, especially those 2,000 feet above mean sea level, have been found to be sensitive to the detrimental effects of acid precipitation. The resulting decline in lake water quality may lead to a loss of fish populations.

Figure 55.--Loss of foliage and early mortality have been documented in many forests; atmospheric pollution is thought to contribute to the problem.

CHAPTER 9

Offsite Effects of Erosion and Runoff Are Serious

Agricultural production can result in damages far beyond the farmer's fields and pastures. Agricultural land is the greatest contributor to nonpoint source pollution. Erosion on and runoff from agricultural land damage water, air, and land offsite. Sediment decreases water storage capacity in lakes and reservoirs, clogs streams and drainage channels, causes deterioration of aquatic habitats, damages water distribution systems, and decreases cropland productivity. These damages have long been recognized. New technology has brought us new problems. Sediment and runoff from agricultural lands can carry chemicals to pollute the water. Irrigation in the West can increase salinity.

Methods to quantify the costs of these damages have not been completely developed. This appraisal reports the estimates available. The offsite costs of water erosion are estimated to be between $3.2 billion and $13 billion annually; the best single-value estimate is about $6.1 billion annually. These figures are preliminary and partial. Efforts are continuing to develop more precise and complete estimates.

Sedimentation Can Damage Land and Water

Each year, about 5 billion tons of soil are detached by sheet and rill, streambank, classic gully, roadside, and construction-site erosion. Much of the detached soil is deposited near the location where movement begins. It settles on features such as terraces, toe slopes, edges of fields, and in furrows and ditches (fig. 56).

About 2.7 billion tons of sediment annually reach small streams. About 60 percent of this is sediment derived from sheet and rill erosion on nonfederal agricultural land. The rest is contributed by other forms of erosion and by erosion on federal land.

The proportion of eroded soil that is delivered to waterways varies widely, depending on site-specific conditions. In general, however, this analysis estimates that about forty percent of the soil annually moved by sheet and rill erosion on agricultural land becomes sediment. Because this appraisal considers all sediment that reaches the waterways of a basin, the estimated rate of sediment delivery is higher than those reported in some other studies that have addressed only the sediment leaving a basin but not the sediment deposited on flood plains and in waterways within the basin.

About 1.1 billion tons of soil are moved by streambank erosion, classic gully erosion, and erosion on roadsides and construction sites. This study estimates that about two-thirds of that soil is delivered to small streams.

The amount of sediment reaching the oceans (500 million tons per year) is less than 10 percent of total erosion and less than 20 percent of sediment entering small streams. The rest of the sediment is deposited on flood plains and in ponds, reservoirs, channels, and wetlands (fig. 57).

Sediment causes damage both while it is suspended in water and when it is deposited within the water channel or on flood plains. Although deposition of fertile sediment on flood plains may increase the fertility of land in some cases, deposition of relatively infertile material over fertile soil can reduce productivity. Complete data are not available to indicate the total acreage that has been altered by recent sediment deposition.

Table 29 shows the acreage in some regions. About 10 to 20 percent of the acreage shown is estimated to

Table 29.--Modern* sediment deposits, selected land resource regions

Region		Mapped areas of sediment deposits
		(1,000 acres)
K	Northern Lake States Forest and Forage	82.9
M	Central Feed Grains and Livestock	2,422.0
N	East and Central Farming and Forest	408.8
L	Lake States Fruit, Truck, and Dairy	256.2
R	Northeastern Forage and Forest	597.9
S	Northern Atlantic Slope Diversified Farming	9.5
J	Southwestern Prairies Cotton and Forage	26.0
O	Mississippi Delta Cotton and Feed Grains	89.1
P	South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock	1,592.1
	Total	5,484.5

*Deposited within the last 200 years.
Source: National Cooperative Soil Survey Program.

Figure 56.--This sediment was eroded from surrounding fields during a single heavy rainfall.

be former cropland or bottomland hardwood forests that have been destroyed by sediment deposition.

Sediment deposited by floodwaters also causes short-term damage to the current crop on fields where a heavy layer of sediment is deposited over a growing crop or plants are covered by a thin film that interferes with photosynthesis and respiration. 1/

Sediment in irrigation water can reduce productivity by forming a crust on the surface of the field. The crust reduces the amount of water that infiltrates the soil, prevents soil aeration, and reduces the emergence of plants.

When sediment is deposited in waterways, it reduces storage capacity and can increase flooding. Of the 690 million acre-feet of total reservoir capacity in the United States, sediment fills an estimated 1 million acre-feet each year. An estimated 15 percent of the reservoirs are losing storage capacity at rates exceeding 3 percent per year, and 2 percent are losing capacity at rates exceeding 10 percent per year. If present sedimentation rates continue, in 30 years about 20 percent of the Nation's small reservoirs will be half filled with sediment, and in many instances, their utility will be seriously impaired.

The Corps of Engineers, between 1979 and 1983, dredged an average 242 million cubic yards annually from rivers and harbors (table 30). About the same amount is removed annually by other government agencies and private concerns.

Sediment suspended in water can drastically reduce the quality of the habitat for aquatic species, reduce the value of the water for recreation uses, and increase the costs of treating water for domestic and industrial use. Sediment is a concern because the particles adsorb other contaminants, such as pesticides and nutrients, and carry them into the water system.

Table 30.--Volume and cost per yard of material dredged by the Corps of Engineers, 5-year annual averages 1979-83

Division	Cubic yards (1,000)	Cost/ yard	Division	Cubic yards (1,000)	Cost/ yard
Lower Mississippi Valley	98,876	$0.72	North Pacific	28,222	$1.42
Missouri River	68	1.49	Ohio River	2,203	1.76
North Atlantic	19,005	2.61	Pacific Ocean	38	7.74
North Central	7,216	3.50	South Atlantic	43,218	1.51
New England	1,007	5.18	South Pacific	9,064	1.93
			Southwestern	23,968	1.00
			Total U.S.	241,885	$1.29

Figure 57.--Parts of this public recreation area, once a manmade lake, can no longer be used because of sediment eroded from nearby construction sites.

1/ Extent of damages caused by flooding and flood-related sediment is discussed in chapter 7.

Erosion and Runoff Can Damage Water Quality

Nonpoint Sources of Pollution

Pollutants can enter waters from either point sources or nonpoint sources. Point sources are those that discharge through a pipe or other easily-identified location. Nonpoint sources are diffused over wide areas. Progress is being made in reducing pollution from point sources, such as municipal and industrial discharges. As point sources are "cleaned up," the relative importance of nonpoint source contributions increases. In 1982, nonpoint sources were ranked as the principal sources of pollution by 26 states and were ranked second by another 13 states. 2/

Data collection on nonpoint source pollution has increased since the passage of the Water Pollution Control Act Amendments of 1972 (Public Law 92-500). These data tend to be fragmentary and generally are site-specific and not applicable to other areas. However, some data are available at the national level (tables 31 and 33).

Although agricultural land is the most extensive source of nonpoint pollution, agricultural areas are not the only source of nonpoint pollution. Other sources include areas of silviculture (forestry), mining and resource extraction, construction runoff, waste disposal, salt water intrusion, hydrologic modification, and urban runoff (table 32). These other sources can produce harmful or objectionable material in sufficient quantities to adversely affect the quality of water used by agriculture.

Table 31.--Estimated nonpoint and point source pollution loadings of major pollutants from nonpoint sources

Pollutant	Nonpoint			Point	Total
	Agriculture	Other	Total		
Pesticides (tons/yr.)	2,064	115	2,179	N/A	2,179
Total phosphorus (thous. tons/yr.)	1,431	182	1,677	330	2,007
Biological oxygen demand (mil. tons/yr.)	27.3	3.1	30.4	3.1	33.5
Total suspended solids (mil. tons/yr.)	1,787	928	2,715	4	2,719

Source: ASIWPCA, 1984.

Table 32.--Sources of pollution

Pollutant/Pollutant category*	Possible sources (alphabetically)
Biological oxygen demand/dissolved oxygen depletion (BOD/DO)	Agriculture (animal & plant waste); Combined sewers; Industries (particularly pulp & paper mills); Municipal wastewater treatment plants; Natural sources
Bacteria (pathogens)	Agriculture (feedlots, manured cropland, pastures, and rangeland); Combined sewers; Municipal wastewater treatment plants; Natural sources
Nutrients	Agriculture; Combined sewers; Construction runoff; Municipal wastewater treatment plants; Natural sources; Septic systems; Silviculture
Toxics	Agriculture (pesticides); Combined sewers; Industries; Land disposal of wastes; Mining (heavy metals); Municipal wastewater treatment plants; Silviculture; Spills; Urban runoff
Dissolved solids (salinity)	Agriculture; Combined sewers; Mining; Urban runoff
Suspended solids	Agriculture; Combined sewers; Construction runoff; Industries; Mining; Silviculture; Urban runoff

* Other categories, not of agricultural origin, are pH (see chapter 8, Atmospheric Deposition) and ammonia.

2/ Association of State and and Interstate Water Pollution Control Administrators. 1984. America's clean water: The states' evaluation of progress 1972-1982. Washington, DC.

POTENTIAL FOR POLLUTION OF SURFACE WATER

This appraisal reports estimates of potential for pollution from agricultural nonpoint sources in each aggregated subarea (ASA) in the 48 conterminous states. The pollutants assessed are pesticides, nutrients, animal wastes, sediment, and salinity. Results from separate analyses of these pollutants were combined to indicate composite potential for pollution (fig. 58). Even though an area may have a low rating of composite potential, it could have a high potential for a specific category of pollution.

Identifying potential for pollution problems is necessary because agricultural nonpoint source pollution is generated by widespread land use activities and is conveyed to waterways through natural processes such as storm runoff or ground water seepage rather than by deliberate, controllable discharge. Monitoring the entire rural countryside for agricultural nonpoint sources of pollution is not practical or affordable.

Many factors affect the potential for a given area of agricultural land to cause pollution of surface water. Population is an important factor because land management is a human activity, and water pollution is defined as a manmade or man-induced condition. Moreover, the use of water by people generally determines water quality needs for an area. The soil type is also important; for example, heavy clay soils may affect surface water quality more than sandy soils; sandy soils may have more potential for contributing to ground water quality problems. Other factors are land use; the proximity of land management activities to water bodies; the ways in which pollutants are transported to water bodies; and runoff, which is determined by climate and the characteristics of the land.

Table 33.--Number of states reporting nonpoint source pollution problems 1/

Source of pollution	Severity 2/			Geographic extent	
	Severe	Moderate	Minor	Widespread	Localized
Agricultural	16	20	8	29	12
Urban	11	20	12	8	35
Mining	15	10	13	2	36
Land-based waste disposal	12	11	17	5	35
Construction	6	23	14	7	34
Dams & channels	7	18	14	5	33
Forests	4	7	21	6	27
Salt intrusion	2	9	10	1	21

Source: Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), 1984.

1/ Number of responding states = 47

2/ In judging severity and geographic extent of nonpoint source pollution, state agencies considered the degree to which each source impaired designated uses.

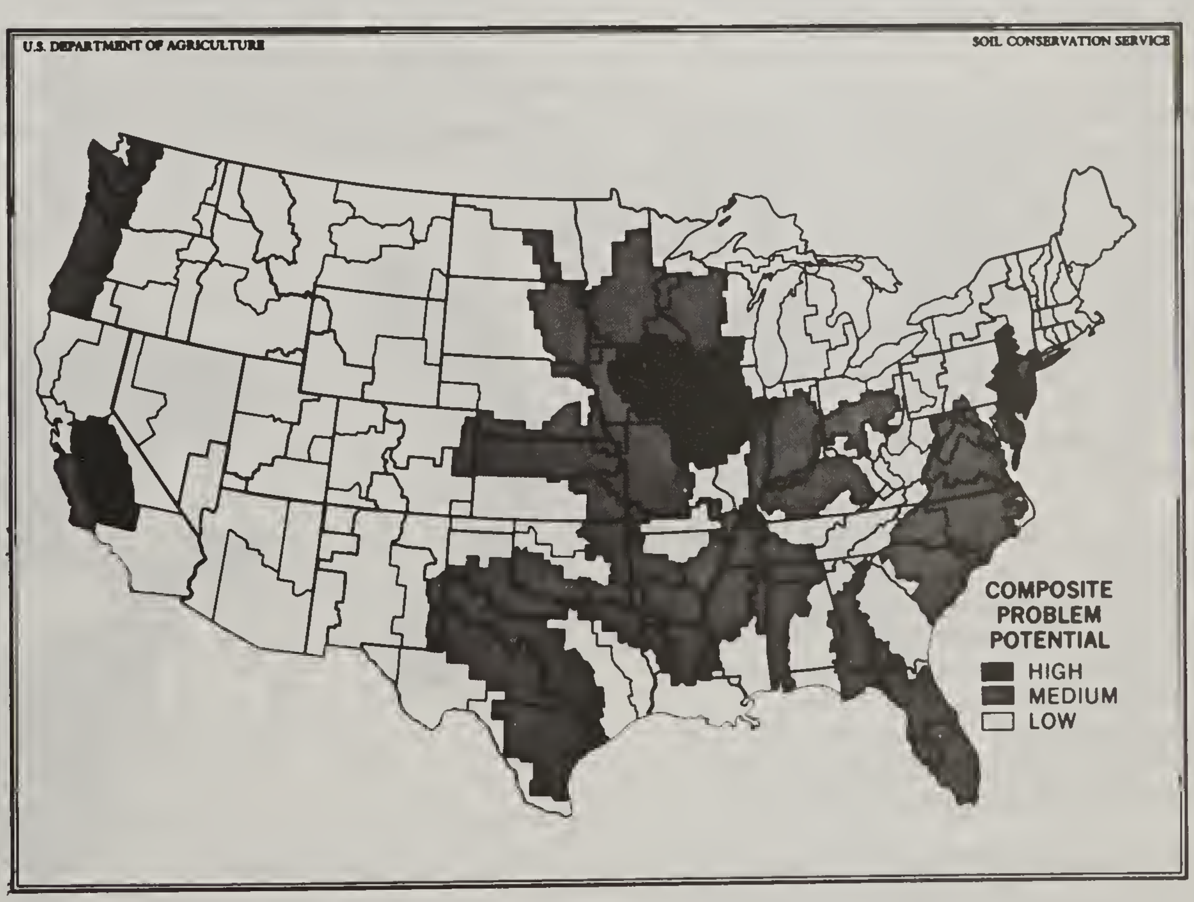


Figure 58.--Composite potential for nonpoint source pollution of surface waters.

An area with a "low" composite rating could have a high rating for a specific contaminant. Ratings were made for multi-county watershed areas and do not identify more localized problems.

Sediment

Erosion is the source of 99 percent of the total suspended solids in the Nation's waterways. Of the 5 billion tons of soil per year detached by sheet and rill, streambank, classic gully, road, and construction-site erosion, about 2.7 billion are delivered to small streams. In addition to this sediment, waterways receive sediment from channel degradation (bottom erosion) on larger streams, flood plain scour, ephemeral gully erosion (concentrated flow erosion on cropland), and mass wasting (landslides, creeps, etc.).

About 37 percent of sediment results from sheet and rill erosion on cropland and pastureland. About 22 percent results from sheet and rill erosion on federal or nonfederal rangeland and forestland. Streambank and classic gully erosion, which account for only 17 percent of the estimated erosion, account for nearly 30 perçent of the sediment yield to small streams.

Sediment that reaches a stream may cause several problems. The most obvious is turbidity. Turbidity is the reduction of clarity and quality of water as a result of the presence of sediment and other suspended materials. Turbidity can reduce the amount of oxygen and light in waters, reducing the quality of the habitat for aquatic species and its value for recreation.

Sediment also contributes to other pollution problems because pesticides, nutrients, and other contaminants are adsorbed to the soil particles. Erosion is the source of 80 percent of the total phosphorus and 73 percent of the total Kjeldahl nitrogen in the Nation's waterways (table 34).

Figure 59 shows the potential for pollution resulting from sediment eroded from agricultural land.

Table 34.--Estimated water pollutant discharge resulting from erosion

Source of pollutants	Erosion	Pollutant discharge: Total suspended solids	Total phosphorus	Total Kjeldahl nitrogen
	(million tons/year)		(thousand tons/year)	
Erosion 1/				
Cropland	1,836	900	615	3,204
Pasture	190	95	91	292
Range	562	253	242	778
Forest 2/	783	344	495	1,035
Other rural lands 3/	453	195	170	659
Streambanks	553	553	1	1
Gullies	295	197	1	1
Roads	167	112	1	1
Construction sites	80	54	1	1
All other 4/	-	16	394	2,186
Total	4,919	2,719	2,007	8,154

1/ Sheet and rill erosion. Does not include ephemeral gully erosion.
2/ Includes federal and nonfederal land.
3/ Includes farmsteads, other land in farms, mines, quarries, pits, and other rural lands.
4/ Includes livestock runoff, dissolved nutrient runoff, acid mine drainage, urban runoff, and point sources.
Source: Resources for the Future, Environmental Discharge Inventory

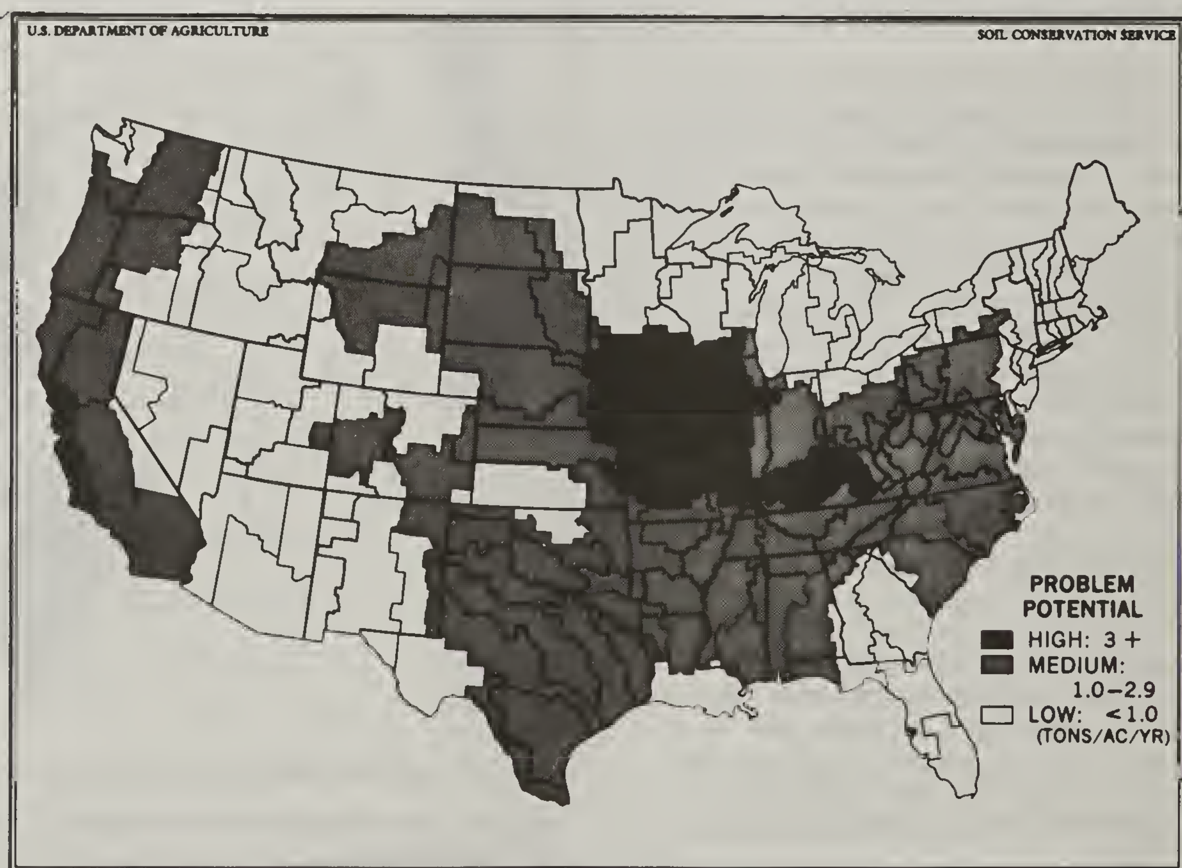


Figure 59.--Potential for pollution of surface water by sediment, as indicated by estimated sediment delivery (tons per acre per year).

Estimated sheet and rill erosion rates reported in the 1982 NRI were adjusted to county boundaries. Sediment delivery for each county and land use was estimated using state sediment delivery curves developed for the 1977 NRI. Sediment delivery rates are assumed to be higher in areas where streams are more numerous and closely spaced and where the surface soils have a higher percentage of fine particles (silt and clay). Data from USGS Surface Soil Surveys and USDA Soil Survey laboratory data were analyzed also.

Pesticides

Chemical compounds used to kill plant and insect pests may become toxic pollutants. In 1984, agricultural pesticides were reported to be a priority pollution problem in 23 States, Puerto Rico, and the Virgin Islands. 3/

Contamination of water by pesticides has been recognized as a problem since the 1960's. The pesticide group of primary concern at that time was the chlorinated hydrocarbons. These chemicals have "biomagnification" effects resulting from their long period of persistence in the environment. Most of them have since been banned for agricultural use. In 1984, the U.S. Geological Survey concluded that chlorinated hydrocarbon insecticides have decreased in both water and streambed material of major rivers. No trends are evident in concentrations of the organophosphate insecticides and herbicides monitored.

The use of more target-specific insecticides, better management, and improved application equipment may be reducing the total quantity of insecticide used. The trend from 1976 to 1982 shows a decline in insecticide use. The trend for herbicide use, however, shows an increase. (See also the ground water section of this report.)

Pollution from pesticides can occur at any location. The more recently developed pesticides are more toxic and less persistent; therefore, any adverse effects on water quality generally will be close to the application site. Pesticides with longer persistence can have an effect farther downstream.

If the less-persistent chemicals cause water quality problems, it can be very difficult to capture the chemicals for study to identify the chemical and its likely source. The chemicals may be diluted, reduced in toxicity, or washed downstream before the stream can be sampled.

3/ United States Environmental Protection Agency. 1984. Report to Congress: Nonpoint source pollution in the United States.

Nutrients

Nitrogen and phosphorus may enter water supplies in runoff and infiltration associated with commercial fertilizer, animal wastes, crop residues, and erosion from cropland. Figure 61 shows the potential for pollution resulting from agricultural nutrients. Potential generally increases in proportion to intensive agricultural land uses, significant cropland erosion, and (to some extent) population density. The areas where potential for pollution is rated high generally are heavy producers of sediment, as some nutrient forms are associated with sediment particles.

Generally, the nutrient forms that affect water quality are particulate and dissolved phosphorus and nitrogen as ammonia, nitrite, and nitrate. The concentration of a nutrient, even more than its form, governs its effect on water quality.

Nitrogen and phosphorus are frequently found in organic associations and are transported in water largely in that form. Nutrients readily change from one form to another, depending on the presence of water and oxygen, ambient temperature, pH, and other environmental factors. Phosphorus, organic nitrogen, and (to some extent) ammonium adhere more or less tightly to mineral or organic particles. Detachment and transport of these particles by water depend upon the kinetic energy of rainfall impacting bare soil and the hydraulic energy associated with overland flow and streamflow.

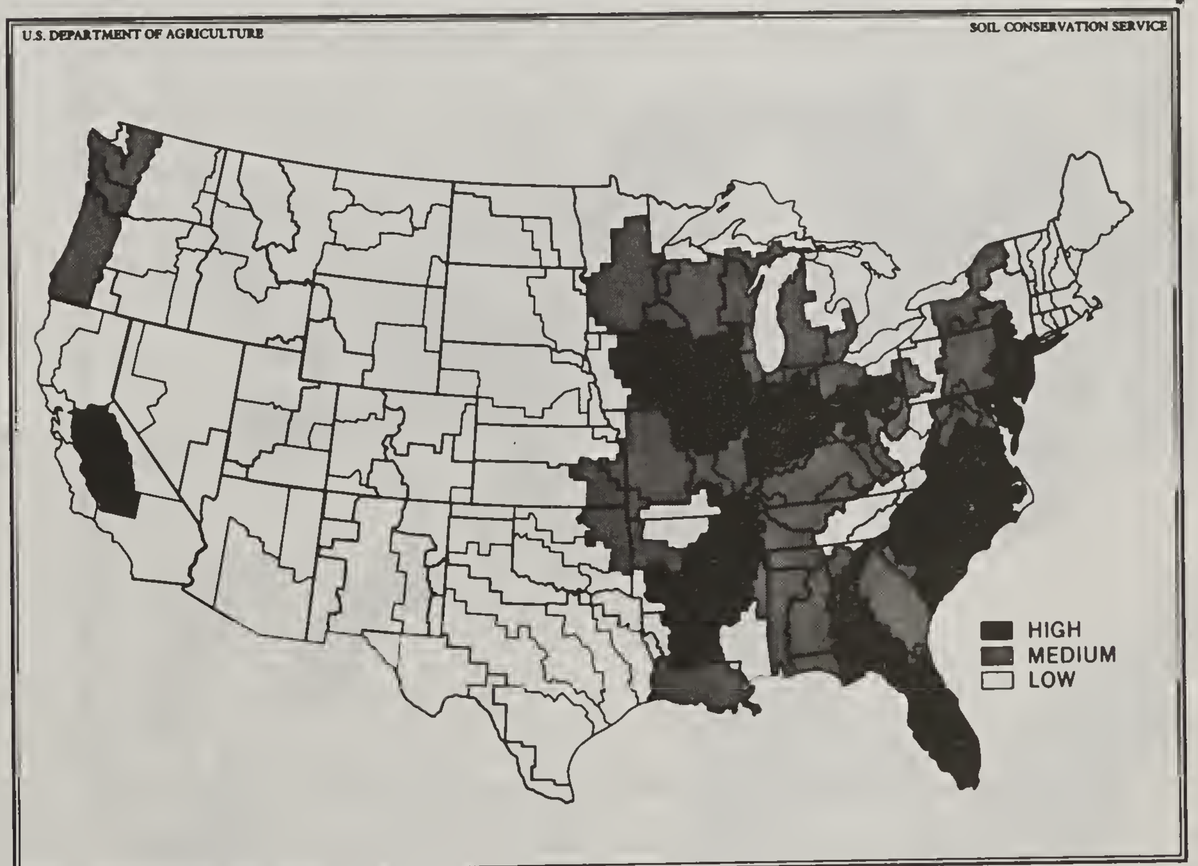


Figure 60.--Potential for pollution of surface water by pesticides.

The potential for surface water pollution by pesticides was estimated by multiplying the crop acreages in each area by pesticide application coefficients for 184 pesticides. These values were multiplied by an availability factor that estimated the percentage of an application leaving a field and were adjusted by a runoff value for the growing season. Pollution potential is estimated for each watershed as a whole; localized conditions may be masked by aggregation. To confirm the existence of pesticide pollution, stream and lake monitoring would be necessary.

Nitrogen and phosphorus may have a toxic effect on water and its inhabitants or may stimulate plant growth. Overabundant nutrients--most often, phosphorus--in a water body can create a condition known as eutrophication, which is characterized by very high vegetative production and very low levels of dissolved oxygen. Periodic "algal blooms" occur, in which a thick green scum of algae covers the water surface. A lake in this condition is unattractive for recreational uses and unfavorable to fish. Eutrophication is a normal process that occurs in the later stages of a lake's existence as the lake fills with sediment. Where the excess nutrients originate from human activity, eutrophication is not a natural process but is a result of pollution.

Health hazards caused by nutrient contamination of private and public water supplies are commonly due to nitrite-nitrogen pollution. Eutrophication is detrimental to fisheries and wildlife, water-based recreation, and esthetic values. Besides the costs of nutrient pollution that farmers share with the general public, there are onsite farm costs caused by wastage of nutrients lost from fields and by lowered crop yields. Individual farm wells and surface water supplies may be harmed by nutrient pollution that makes the water unfit for use.

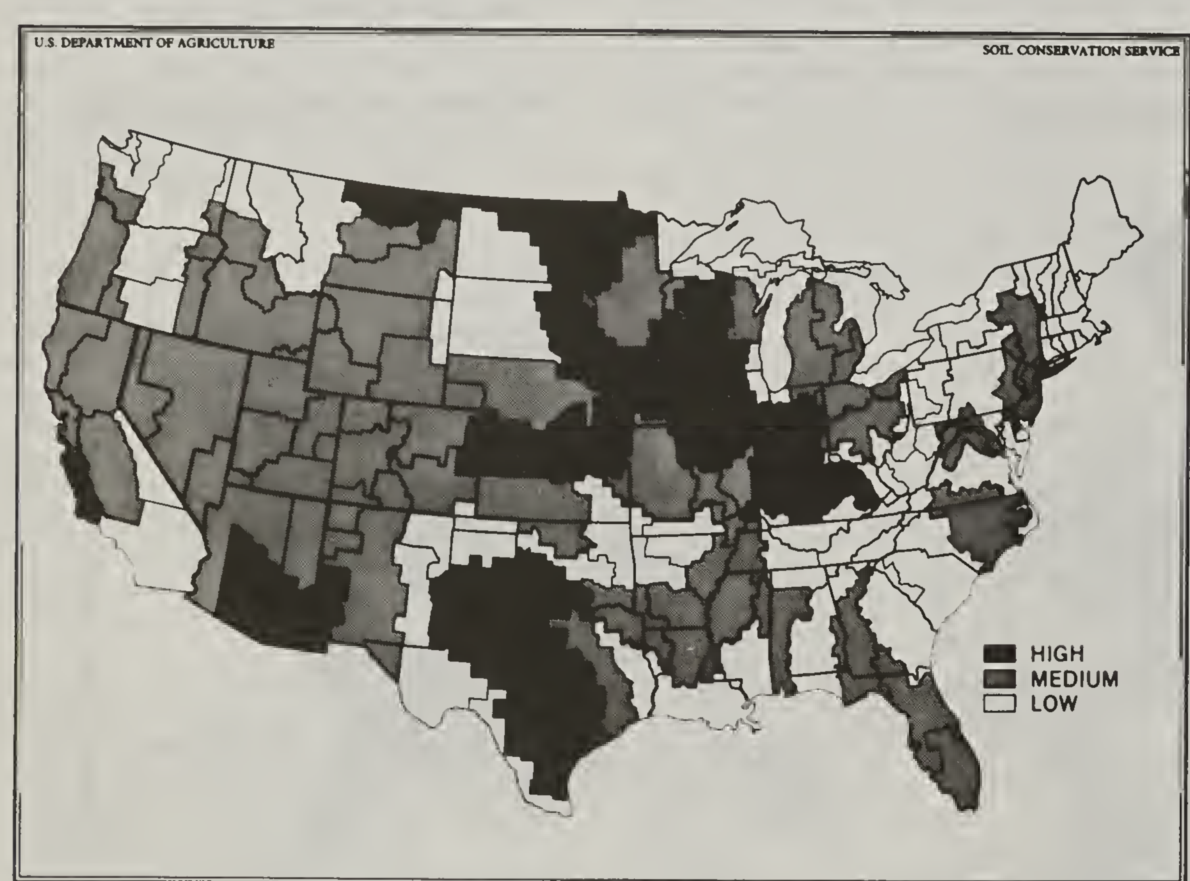


Figure 61.--Potential for pollution of surface water by nutrients.

The potential for impairment of water quality was estimated by determining nutrient concentrations, by form, and comparing them with the respective threshold levels at which they threaten desired water uses. Data on nutrient concentrations were taken from WATSTORE (U.S. Geological Survey data from water quality stations). Stations were primarily National Stream Quality Accounting Network stations at the downstream end of hydrologic accounting units. Estimates of pollution potential are for the watershed as a whole and may not reflect localized conditions.

Animal Waste

The major pollutants in animal wastes are nutrients (mainly nitrogen and phosphorus), pathogenic bacteria, and organic material. Areas where livestock are concentrated and fields and pastures where manure is spread can be sources of pollutants.

The potential for animal waste problems is high in areas with very large populations of livestock, notably in the southeastern and southwestern parts of the United States. The large quantities of manure produced in these areas need management, often in areas where cropland and grassland are in short supply. In relatively dry regions where crops are irrigated, the application of irrigation water and manure on cropland and grassland increases the potential for problems. These warmer, dryer areas have open feedlots, where rainfall concentrates nutrients and organics in runoff. Potential for problems is also higher in the humid areas along the Gulf of Mexico and the Atlantic seaboard, where there is more rainfall.

Although this analysis does not indicate areas in the northeast as highly critical, conditions there do suggest potential could be high. Much of the farmland in the north is sloping to steep, and perennial streams are abundant. The growing season is short and the soil is frozen or snow-covered for long periods. Livestock enterprises must keep animals confined during the winter. Confined livestock operations generate large quantities of manure that must be handled, and less time is available to spread it. Unit costs of developing and operating waste management systems are higher than in southern areas. Often these costs are high enough to impede installation of improved systems.

In the Corn Belt, large livestock enterprises are generally associated with commensurately large areas of highly productive cropland with moderate to flat topography. Livestock producers grow much of their own feed and cycle the manure. Managing manure here takes less intensive management than in other areas. The analysis indicates that these

areas have a low to moderate potential for pollution. However, certain localized conditions cause problems that are masked because of the large area of consideration. In some areas in the Northeast and Corn Belt, large numbers of animals are concentrated on relatively small acreages of farmland, but pollution potential is low to moderate because many manure management systems have been implemented in the past 15 years.

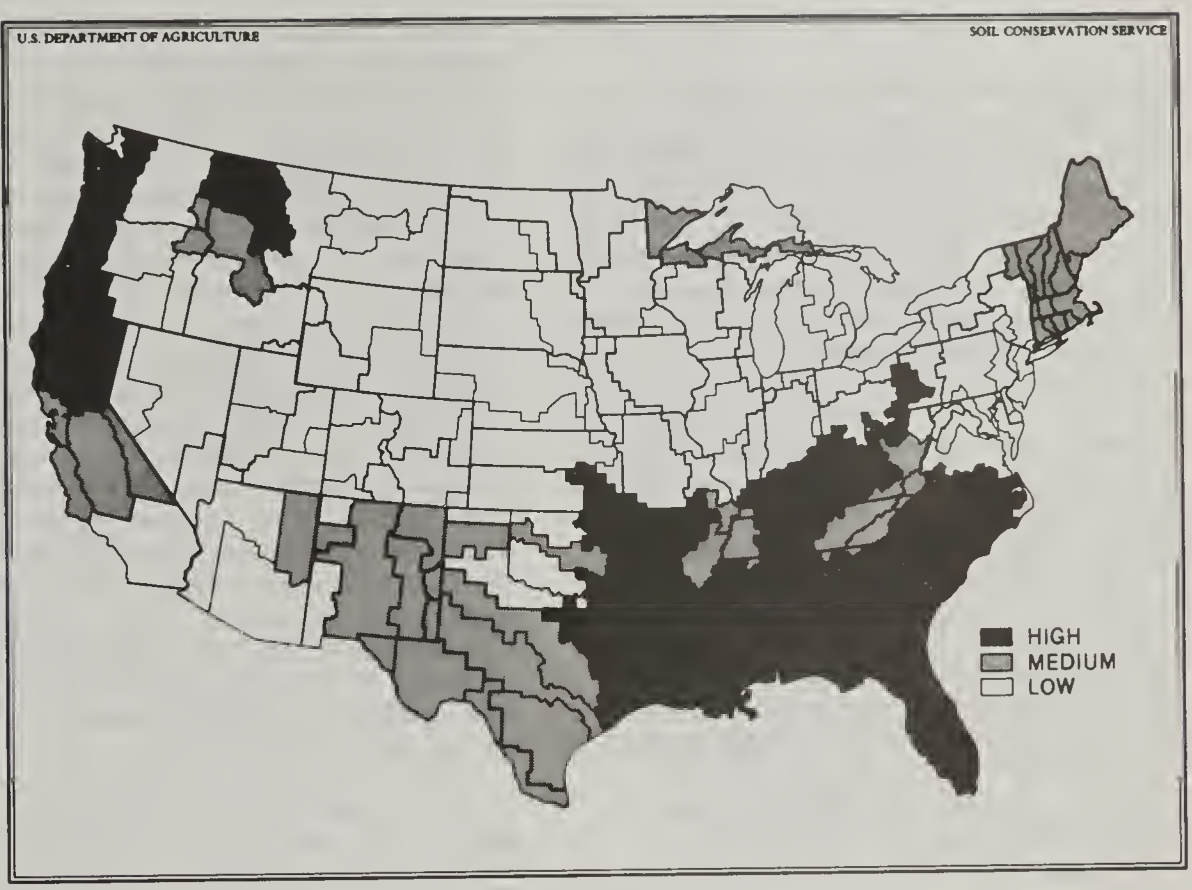


Figure 62.--Potential for pollution of water by animal wastes.

The figure shows potential for pollution resulting from animal wastes, taking into account percentage of manure needing improved management, percentage of cropland and grassland associated with animal enterprises, runoff from precipitation, ratio of feed purchased to feed produced on farm, and ratio of nitrogen and phosphorus available from manure to nitrogen and phosphorus needed by crops.

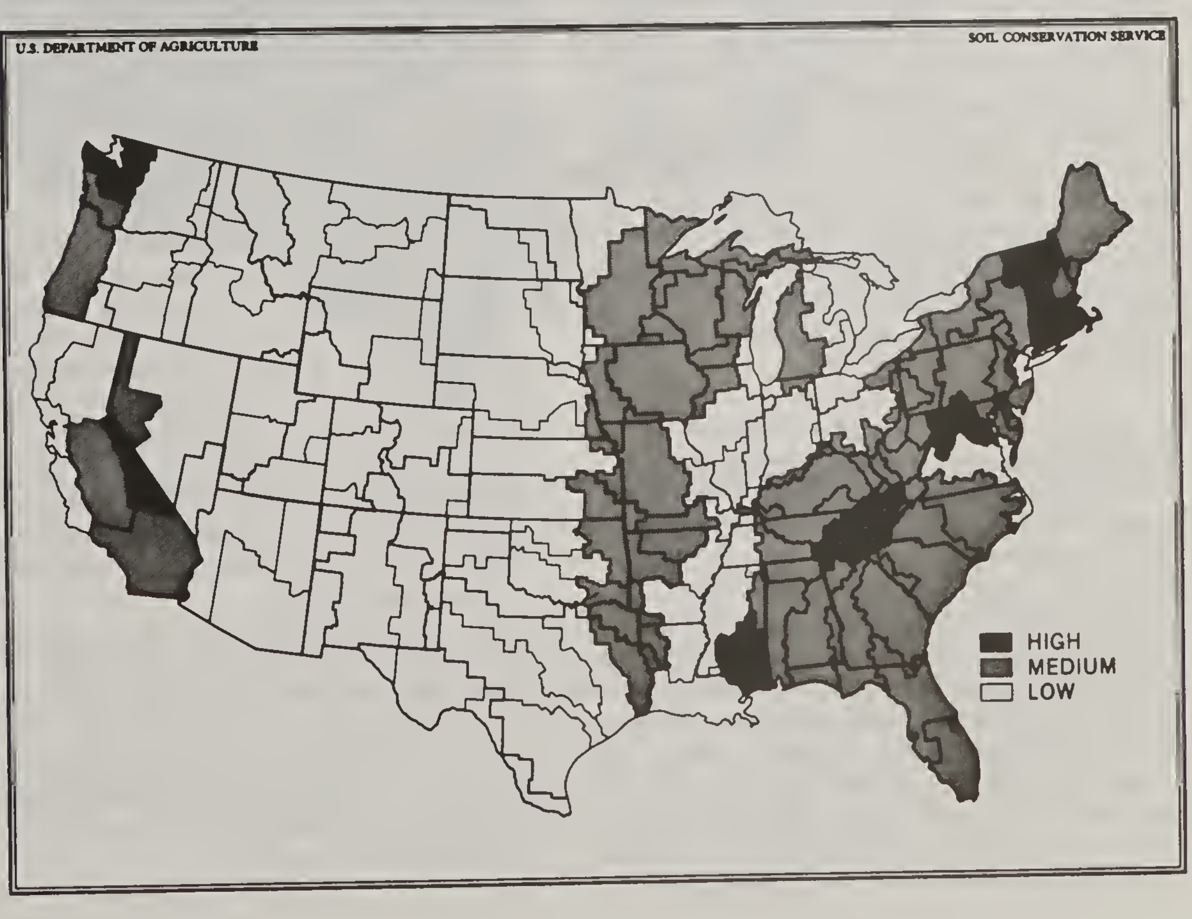


Figure 63.--Animal wastes produced per acre of cropland and grassland.

The number of each type of animal in a county (from the 1982 Agricultural Census) was multiplied by the appropriate manure production factor. The amounts of manure produced by all the county's livestock were totaled and aggregated by area; the total was divided by the acreage of cropland plus grassland (from the Agricultural Census) in each area.

Salinity

Salinity in surface water and ground water results from both natural and human causes. Natural causes include salt contribution of saline springs, weathering of the earth's surface through erosion and solution, and the concentrating effects of evaporation and transpiration. Human-caused saline problems result from the acceleration of erosion, the concentrating effects of agricultural consumptive use of water, and deep percolation of irrigation waters that dissolve salts from underlying rock formations. This study looked at salinity resulting from human activities. Surface water and ground water are so interrelated that no distinction can be made between salinity problems which reside primarily in one or the other. Figure 64 shows areas with potential for salinity problems.

Most salts are readily soluble in water and thus are subject to transport. Salts are carried as dissolved solids and as suspended solids attached to sediment. On the average, rivers across the country carry a heavier weight of minerals as dissolved solids than as suspended sediments (table 35). Yet the problems of soil salinity and high salt concentrations in streamflows are almost exclusively limited to arid and semiarid regions. Concentrations of dissolved solids in rivers draining the more humid areas of the midwestern, eastern, and Pacific states rarely exceed 300 milligrams per liter (mg/l), whereas salt concentrations commonly exceed 800 mg/l in streams in the watersheds of the Rio Grande and Colorado Rivers and in the Great Basin.

A major factor is the amount of water available year-round for transporting the salts. Other factors are the geologic age of the landscape and the accessibility of salt-bearing geologic formations. The geologic youthfulness of the West in comparison with the great river basins of the eastern United States means that water has not had as much time to leach salts from the soil and adjacent formations. In the arid and semiarid west, the most saline formations tend to be near the valley floors. These lowland areas also tend to have the lowest annual precipitation and the least opportunity for natural leaching of salts from the soils and underlying formations. Many soils remain quite saline even after hundreds of thousands of years of exposure to the hydrologic cycle.

In the western United States the largest agriculture-induced increase in salinity is due to the concentrating effects of evapotranspiration and loadings associated with irrigation (see chapter 4). On most irrigated fields, the water that infiltrates the soil is more important in moving salts than is the surface runoff. In a few places, however, so much irrigation-related erosion occurs that heavy loads of salt are carried off in conjunction with the transported sediments.

Water normally becomes more saline as it moves downward through a river basin. Irrigation tends to aggravate this increase in salinity by:

- accelerating the leaching of salts through irrigated soils, subsoils, and geologic formations;
- inducing the erosion and transport of salty sediments; and
- concentrating salts in surface water and ground water when part of the irrigation water is used by plants or evaporates from wet soils or water surfaces.

Table 35.--Relative transport of dissolved and suspended solids

Selected streams near oceans in the conterminous 48 states Sampling location	Weight of material transported Dissolved solids	 Suspended sediments	Ratio of dissolved to suspended material
	----kg/day(avg.)---		
Saco R. at Cornish, ME	1.60E+05 1/	7.70E+04 1/	2.08
Connecticut R. at Thompsonville, CT	2.40E+06	1.40E+06	1.71
Hudson R. at Green Island, NY	3.60E+06	9.80E+05	3.67
Delaware R. at Trenton, NJ	2.30E+06	1.50E+06	1.53
Potomac R. at Chain Bridge, DC	4.00E+06	3.40E+06	1.18
James R. nr. Cartersville, VA	1.30E+06	1.40E+06	0.93
Pee Dee R. nr. Rockingham, NC	1.10E+06	9.00E+05	1.22
Edisto River nr. Givhans, SC	2.60E+05	2.90E+04	8.97
Savannah R. nr. Clyo, GA	1.50E+06	5.90E+05	2.54
Satilla R. nr. Atkinson, GA	1.70E+05	1.00E+05	1.70
Peace R. at Arcadia, FL	2.60E+05	4.00E+04	6.50
Alabama R. nr. Claiborne, AL	6.40E+06	8.80E+06	0.73
Pascagoula R. nr. Benndale, MS	1.20E+06	4.50E+06	0.27
Mississippi R. nr. Belle Chasse, LA	2.70E+08	1.00E+09	0.27
Guadalupe R. at Victoria, TX	1.70E+06	2.70E+06	0.63
Rio Grande R. nr. Brownsville, TX	3.40E+06	3.00E+06	1.13
Sacramento R. at Freeport, CA	4.30E+06	3.80E+06	1.13
Klamath R. nr. Klamath, CA	3.00E+06	1.10E+07	0.27
Tualitin R. at West Linn, OR	2.00E+05	1.00E+05	2.00
Willamette R. nr. Portland, OR	3.60E+06	1.80E+06	2.00
Columbia R. at Warrendale, OR	4.30E+07	9.30E+06	4.62
Skagit R. nr. Mount Vernon, WA	1.30E+06	3.20E+06	0.41
Average ratio			2.07

1/ Values are in scientific notation: 1.60E+05 = 1.60×10^5 and 7.70E+04 = 7.70×10^4.

Source: Derived from unpublished data produced by the National Stream Quality Accounting Network (NASQAN) program, administered by the U.S. Geological Survey.

In the last case, the concentration of salts increases, but the volume of salts transported does not.

When salt concentration is combined with limited soil drainage, applying irrigation water tends to stop or reduce the transport of salts and to cause them to accumulate at the site.

The most critical salinity problems are commonly hundreds of miles from the source of the salt. Water use impairments caused by salinity can be broadly classed as agricultural and nonagricultural impairments. By far the most common agricultural impairment is reduced crop yields. Another possible impact is physiological upset and death of livestock.

Non-agricultural impairments of water supplies caused by salinity are often ill-defined. Salinity in water can increase human health risks, reduce the effectiveness of household cleaning compounds, cause metal corrosion, and coat the inside of pipes and boilers. The effect of salinity on aquatic habitat is less clear than other impacts, but in general increased salinity levels increase mortality and reduce the growth rate of most freshwater species.

Salts and salinity have a definite effect on household cleaning, particularly as they constitute hardness. Generally, water hardness is measured in units of milligrams per liter (mg/l) of calcium carbonate. Hardness varies from soft (0-8 mg/l) to very hard (above 200 mg/l). The main disadvantage of hard water for cleaning is that calcium and magnesium ions react to soaps by forming soap curds, which wastes the soap and adds to the cleaning problem. Dissolved solids may cause other cleaning problems such as water spotting on glass.

Salinity greatly complicates water treatment and consequently increases treatment costs. Dissolved solids do not respond to the usual settling and filtration techniques used for suspended materials. Removing dissolved substances requires ion exchange, chemical precipitation, distillation, or the latest method of reverse osmosis.

Corrosion caused by specific ions is a widespread problem in individual and municipal water supply systems. A 1976 study estimated that almost half of the 100 largest cities in the United States distribute water that is in some degree corrosive.

The presence of calcium carbonate can benefit plumbing for a time because, at the proper pH, calcium carbonate is deposited inside the pipes, providing some protection against corrosion. As deposition increases, however, plumbing and household appliances often become clogged and require replacement.

Salinity has similar effects on industrial water users. As with domestic use, a fine line separates industrial deterioration caused by corrosion and that caused by the clogging effect of calcium carbonate.

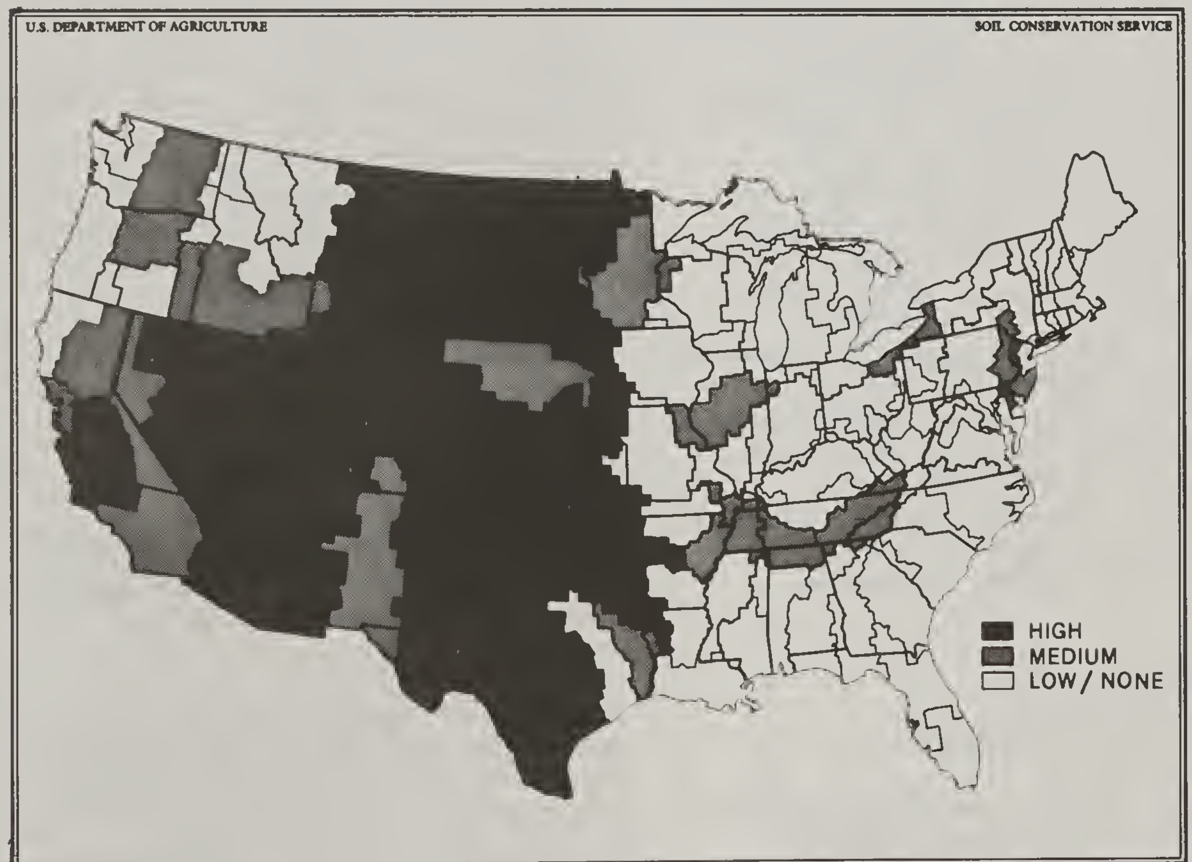


Figure 64.--Potential for pollution of water by dissolved solids (salinity).

To assess potential, indicators of total dissolved solids, adjusted sodium adsorption, and chloride concentration were checked and total solid loads were analyzed using data for agricultural acreages, areas affected by saline or sodic soils, and irrigated acres as modifying and/or contributing factors. Data analyzed were taken from the U.S. Geological Survey National Stream Quality Accounting Network stations and published and unpublished data from EPA and USGS.

POLLUTION OF GROUND WATER

Ground water is the water contained in fractures, cracks, cavities, and pore spaces in subsurface geologic formations. The amount of stored ground water beneath the land areas of the world is about 35 times greater than the combined amount of water in all rivers, freshwater lakes, saline lakes, and inland seas.

Geologic formations permeable enough to yield appreciable amounts of ground water to wells are termed aquifers. In the United States, aquifers are present practically everywhere but vary widely in the yields water wells can deliver. About half of the water used for drinking water supplies in the United States comes from wells.

Ground water naturally contains various mineral substances that have been dissolved from the local geologic formations. In general, the longer the water remains in the earth, the higher the concentrations of dissolved substances. Water in deep aquifers thus tends to be more mineralized than water in shallow aquifers. Faults in rock systems may act as conduits for ground water flow or may be sealed so tightly with clay or mineral deposits that the ground water flow is blocked.

Improper disposal of manmade waste or overapplication of other materials may add extraneous substances to ground water. These actions may degrade the quality of the ground water so that it no longer meets standards for a specific use.

In 1984, forty-two states reported some information on ground water conditions. 4/ This information is largely anecdotal and must be tied to information gained through other studies. Thirty-five states reported some problems with ground water contamination. The most commonly reported sources of contamination are industrial and municipal landfills and lagoons, underground storage tanks, pesticide applications, septic tanks, and chemical, oil, and brine spills. The most commonly reported pollutant groups are chlorinated solvents, pesticides, miscellaneous hydrocarbons (such as gasoline), metals, salinity, and radionuclides. Several states reported problems with ground water depletion and saltwater intrusion.

Contamination of Ground Water by Agricultural Chemicals

Although there is no national data base to confirm it, there are examples of the contamination of ground water by nonpoint sources. Ground water pollution from prior and current agricultural use of pesticides and nutrients is being documented. Synthetic organic pesticides are of concern because of their environmental persistence and potential health effects. Nitrates in ground water from fertilizer applications and animal waste have long been recognized. Table 36 summarizes a report on ground water contamination by agricultural chemicals that was prepared for this appraisal by the Environmental and Ground Water Institute of the University of Oklahoma. The agricultural chemicals studied were pesticides and nutrients (primarily nitrogen) originating from applications of fertilizer or of animal wastes.

Many states have only limited information on pesticides and nutrients in ground water. However, interest in these contaminants is increasing, and many efforts to gather data are under way. Limited funding for monitoring programs appears to be a major cause of this lack of knowledge. Many field studies have been conducted across the Nation on agricultural contamination of ground water, but most of them focused on nutrients. Information is being accumulated on management practices that reduce loss of nitrate fertilizer to ground water. Pesticide contamination has drawn less attention. Research on the stability and transport of pesticides in ground water is increasing.

A large number of states do not have laws or regulations governing the application of pesticide or fertilizer. Many existing laws and regulations need updating. In some states the institutional authority for addressing pesticide contamination of ground water is still unclear.

At present, nitrates in ground water are regulated under stricter standards than are pesticides. The large number of pesticides and the lack of information on their persistence in ground water make it difficult to set standards defining pesticide contamination.

Several federal laws directly address agricultural chemicals. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) allows EPA to ban or restrict pesticides that pose an imminent risk because of their ability to leach through the soil profile. Under the Safe Drinking Water Act, states are to develop programs for preventing contamination of ground water around public wells.

Saltwater Intrusion into Ground Water

Water obtained from wells is frequently contaminated by saltwater intrusion. The salinity of ground water generally increases as depth increases. This phenomenon is related to the original deposition of the salt-bearing formations, the movement of ground water, and the movement of individual ions over time.

However, the salinity of ground water is also traceable to other factors, such as proximity to oceans, leakage of wells, upconing of salt under wells, and leaching from surface sources. 5/ The effects of salinity may extend for 20 or 30 miles or even more from the source of the salinity toward the area where ground water is being withdrawn.

In 1977, the Environmental Protection Agency conducted a survey of saltwater intrusion. The EPA study does not include a precise assessment of intrusion linked to surface infiltration from agricultural practices. The most frequent cause of saltwater intrusion is excessive pumping, or ground water mining, which has caused lateral intrusion of salt water in 27 states and vertical intrusion in 11 states, according to the EPA study. Agriculture is not implicated except as a heavy user and consumer of water. Other sources of saltwater intrusion, reported in only a few states, are improper disposal of oilfield brines, faulty well casings, layers of salt water in thick limestone formations, and dredging (which may cause vertical intrusion or upwelling of salt water). Of these, only faulty well casings (six states affected) may relate to surface infiltration from irrigation.

4/ U.S. Environmental Protection Agency. 1984. National water quality inventory: 1984 report to Congress.

5/ For additional discussion of saltwater intrusion problems, by state and region, see Environmental and Ground Water Institute, University of Oklahoma. "Salt water intrusion of ground water in the contiguous United States," Chapter IV, Volume III, Part A.

Table 36.--Ground water contamination by nutrients and pesticides ("n" means nutrients; "p" means pesticides. Absence of an entry indicates either that no significant contamination is apparent or that data were not available.)

Region	State	Confirmed 1/ Regional	Confirmed 1/ Localized	Suspected	Nonagricultural 2/
NORTHEAST:	Connecticut	n, p			
	Delaware	n	p		
	Maine	n, p			
	Maryland		n, p		
	Massachusetts	p			
	New Hampshire				
	New Jersey	n, p			
	New York	n, p			
	Pennsylvania		n, p		n
	Rhode Island	p			
	Vermont		n, p		
LAKE STATES:	Michigan		n, p		
	Minnesota		p	p	n
	Wisconsin		n, p		
CORN BELT:	Illinois		n, p	n, p	
	Indiana		n, p		
	Iowa	n	p		
	Missouri		n, p		
	Ohio		n, p		
NORTHERN PLAINS:	Kansas		n, p		
	Nebraska	n, p			n
	North Dakota				
	South Dakota	n, p			n
APPALACHIA:	Kentucky			n, p	
	North Carolina		n		p
	Tennessee		n, p		
	Virginia			n, p	
	West Virginia		p		
SOUTHEAST:	Alabama		n, p	n, p	
	Florida	n, p			
	Georgia	n	p		
	South Carolina		p		n
DELTA STATES:	Arkansas				
	Louisiana		p		
	Mississippi				
SOUTHERN PLAINS:	Oklahoma	n			p
	Texas	n, p	n, p		
MOUNTAIN:	Arizona		p		n
	Colorado		n, p		
	Idaho		p	p	n
	Montana		p		
	Nevada				n
	New Mexico		n	p	
	Utah		p	n	
	Wyoming			n, p	
PACIFIC:	California	n, p			
	Oregon 3/	n, p			n, p
	Washington	n, p			
	Totals:	15n, 13p	16n, 25p	6n, 8p	9n, 3p

1/ Contamination has been documented by ground water monitoring or by published studies.
2/ Contamination exists but is due to handling or to nonagricultural activities (for example, phosphate mining).
3/ Data added by the state.

REDUCING POTENTIAL FOR POLLUTION: What can we do?

The potential for contamination of water by agricultural nonpoint sources can be controlled in three basic ways. The efficiency and attractiveness of each of these strategies depend on the particular situation being addressed and the relative magnitudes of on-farm and off-farm effects.

One approach is to allow the problems to occur and to compensate for them afterward. This approach results in costs such as dredging reservoirs and treating drinking water supplies, which are described in following pages.

The second approach is to permit problems to occur but attempt to collect pollutants after they leave a site but before they enter a waterway. For agricultural pollutants, this policy can involve constructing sedimentation basins and filter strips along streams.

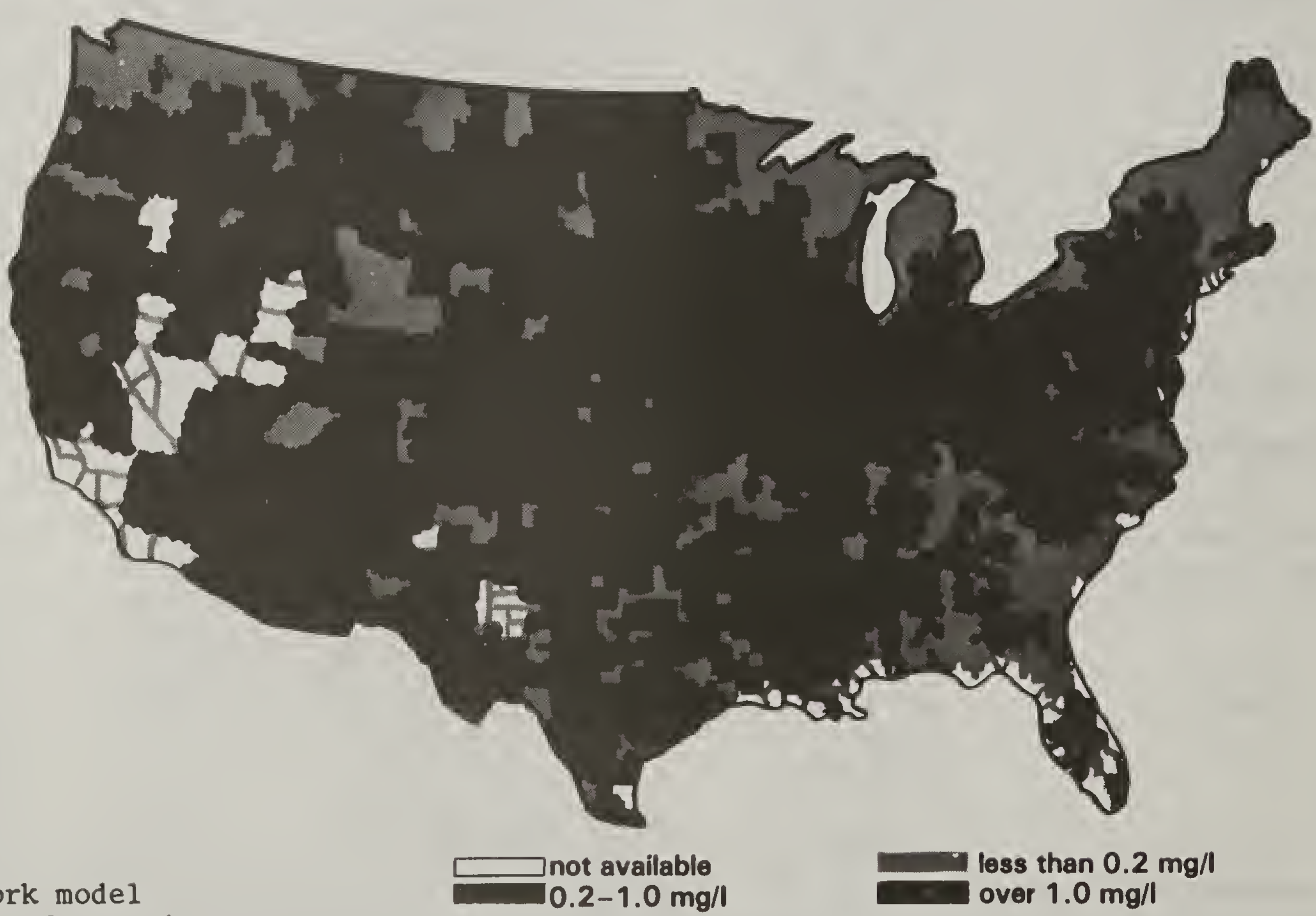
The third approach is to prevent pollutants from being created in the first place. In the case of soil erosion, this means preventing erosion and preventing the associated contaminants from being carried off the land. This can be accomplished by installing resource management systems.

For a resource management system to be effective in reducing nonpoint source pollution, it must decrease the availability, prevent the detachment, or stop the transport of the pollutants. A system that adequately controls the target pollutant is the "best resource management system" for solving the existing water quality problem. However, systems that solve one water quality problem must not increase the potential for another problem.

The same kinds of soil and water conservation practices that are applied to protect or improve soil resources are used where protecting surface water quality is an objective. Resource management systems may include one or a combination of management, vegetative, and structural practices.

Management practices, such as nutrient management and pesticide management, limit the availability of the pollutant to runoff. This is done by carefully incorporating the chemical into the soil, scheduling its application during low-runoff periods, reducing the quantities applied, or changing the form in which it is applied. Management practices have a great advantage because they are flexible and relatively low in cost, can be quickly initiated, and often reduce the land user's costs. However, a disadvantage is that a land user can quickly weaken the measure's effectiveness by not following good techniques.

Vegetative practices limit the movement of pollutants by reducing soil erosion. They protect the



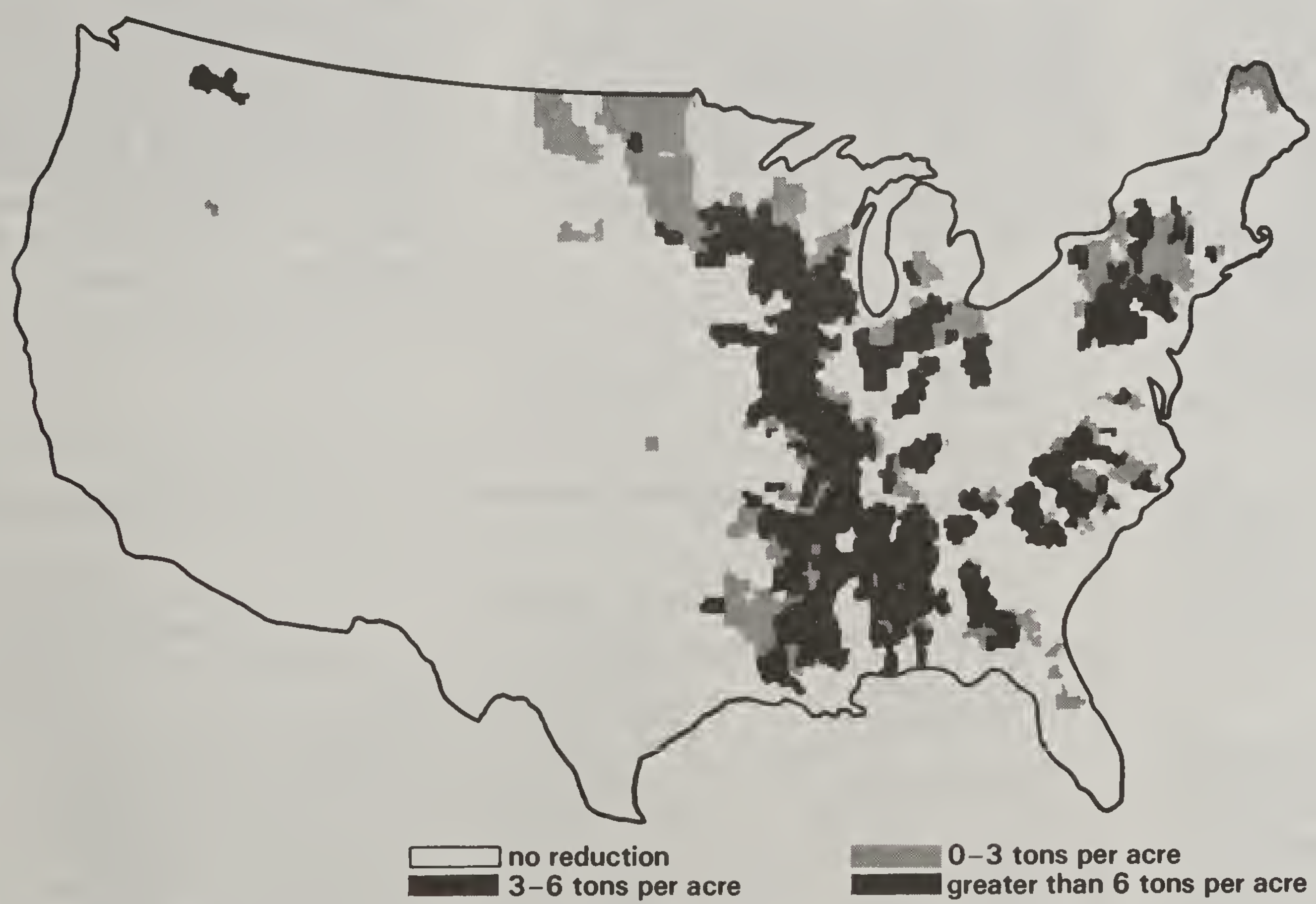
Estimated conditions are for a typical rainy spring day in all locations. The model includes both point and nonpoint sources of pollution. It takes into account the effect of water flow on the pollution potential of erosion.

Source: National water network model developed by Resources for the Future.*

Figure 65.--Estimated phosphorus concentrations in rivers and streams.
*Resources for Future is an independent organization founded in 1952 that conducts research in the development, conservation, and use of natural resources and on the quality of the environment.

soil from the impact of raindrops and overland flow. They are effective where pollutants are attached to sediment or where sediment is a pollutant. Vegetative practices such as crop rotations and winter cover crops protect the soil and increase infiltration while decreasing runoff. Advantages are that they are flexible and are generally relatively inexpensive to implement; however, the landowner's income may be reduced when a rotation requires more sod crops. A disadvantage is that the land user can undo any benefit by plowing at the incorrect time of the year.

Structural practices are alterations of the landscape. They reduce the length of the slope to control the amount of runoff and reduce the steepness of the slope to control the velocity of runoff. Other practices, such as grassed waterways, use a combination of structural and vegetative practices to reduce the depth of flow. The main advantage of structural practices is permanence. They generally become part of the farming system for a substantial period. Disadvantages are that they can be costly to install and need continued maintenance.



Source: National water network model, Resources for the Future.

Figure 66.--Counties where reduction of sheet and rill erosion on cropland would bring phosphorus concentrations in surface waters into compliance with EPA's recommended standard.

Shaded areas are counties where reducing erosion on cropland would reduce phosphorus loads to EPA's recommended standard of 0.2 mg/l. Successive simulations by RFF's national water network model determined the level of reduction in cropland erosion that would be required.

"No reduction" means either that the original phosphorus loading was less than the standard or that phosphorus loadings would continue to exceed the standard even if erosion on cropland were totally eliminated. For some counties, the reduction indicated is needed to reduce phosphorus downstream.

Analysts first simulated the effects of totally eliminating cropland erosion as a source of phosphorus loadings and noted areas for which that elimination sufficed to reduce loadings to 0.2 mg/l. The model was then allowed to project increasingly higher erosion rates until it reached the highest rate that resulted in phosphorus loadings of no more than 0.2 mg/l.

Reducing Cropland Erosion to Protect Water Quality: An Effective Strategy?

Land used as cropland is more vulnerable to onsite damage caused by erosion than land in other uses; 60 percent of the nonfederal agricultural land eroding at excessive rates is cropland even though cropland makes up only 30 percent of nonfederal land. Land used as cropland does not contribute so disproportionately to sediment that reaches waterways. Cropland makes up about 22 percent of the total area of the 48 contiguous states and is estimated to be the source of about 30 percent of total suspended solids in the Nation's waters. 6/

In areas where cropland is a major land use, reducing erosion on cropland could significantly reduce loadings of some contaminants. For example, erosion is the source of 80 percent of the phosphorus in surface waters, and cropland erosion alone is responsible for an estimated 30 percent. Phosphorus loadings in many of the Nation's waterways periodically exceed the U.S. Environmental Protection Agency's recommended standard of 0.2 milligrams per liter (fig. 65). A study conducted for this appraisal indicated that, in some counties where cropland is a major land use, reducing erosion could reduce phosphorus loadings to the recommended level or less even if no other action were taken to protect water quality (fig. 66).

The study identified 47 watersheds (called aggregated subareas) where total phosphorus concentrations in 1982 exceeded EPA's recommended standard and where reduction of cropland erosion alone would reduce phosphorus loadings enough to meet the standard (fig. 67). Because sediment and sediment-related pollutants can affect water quality far downstream from the point they enter the water, the study identified some areas where erosion control would be needed to improve water quality downstream even though phosphorus loadings in the watershed itself either did not exceed the standard or would continue to exceed the standard even if no cropland erosion occurred.

Sheet and rill erosion on cropland would have to be reduced by nearly 561 million tons in the 47 watersheds. Reducing erosion in those areas would involve some shifting of production to other areas. Erosion rates would be increased in these areas but not to the extent that the water quality standard would be exceeded. The study projects that erosion at the net reduction in erosion at the national level would be 282 million tons.

The projected cost of production was 0.66 percent higher with the erosion restrictions than without them. Some shifting of production among regions was projected. These inter-regional shifts in cropland use are projected because the actions needed to reduce erosion in the selected regions create changes in comparative advantage among regions in crop production, transportation, and livestock feed requirements. For example, the erosion reduction simulated in the Lake States was substantial. To achieve this much reduction, the model projected soybean production, which on many soils is accompanied by high rates of sheet and rill erosion, to decrease by a million acres in the region.

In parts of the country where cropland is not the dominant land use, however, cropland's contribution to sediment-related pollutants such as phosphorus is relatively minor. Erosion from land in other uses (such as rangeland and forests) may contribute more than half of the total nonpoint pollutant load, and other sources such as streambank erosion are important. In those areas, improving water quality would require strategies that consider other sources in addition to cropland.

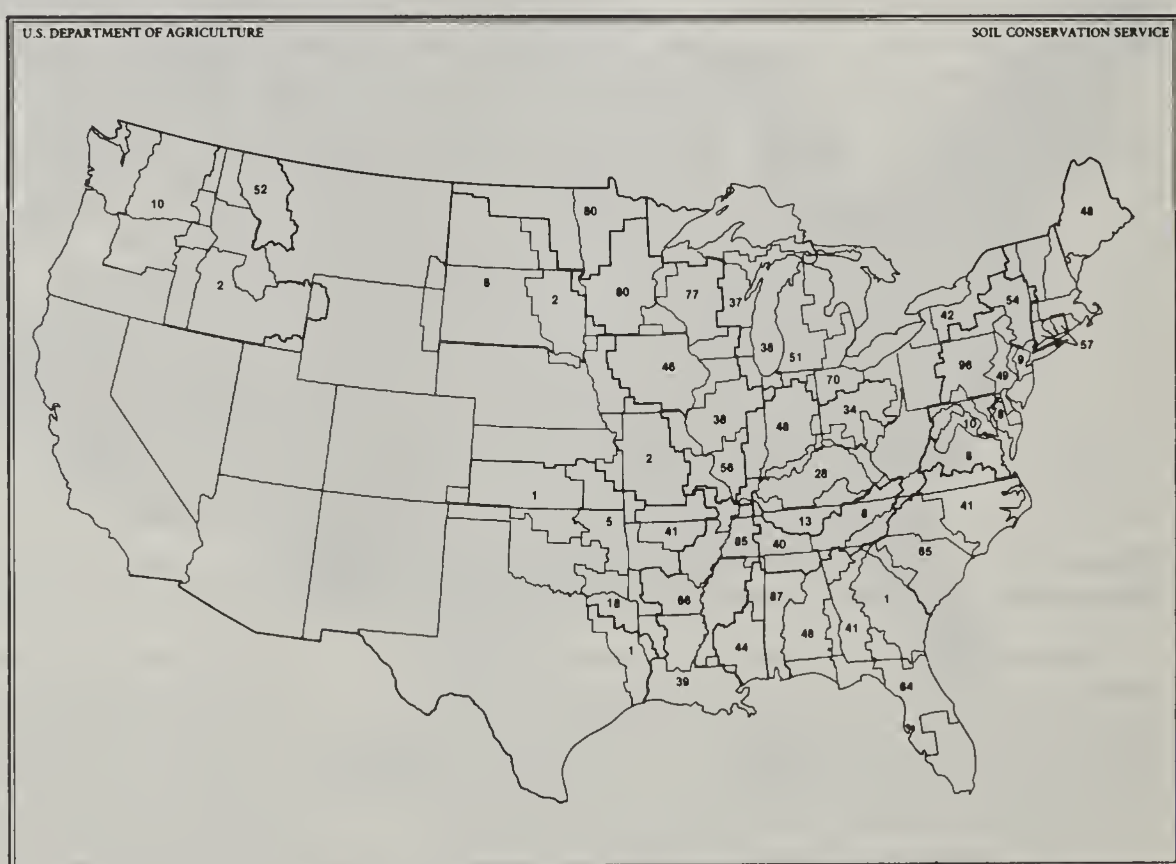


Figure 67.--Percentage of erosion reduction from 1982 NRI levels that would be required to reduce phosphorus loading to EPA recommended levels, by aggregated subareas.

6/ Gianessi, Leonard P., Henry M. Peskin, Pierre Crosson, and Cyndi Puffer. 1986. Nonpoint source pollution: Are cropland controls the answer? Resources for the Future, Washington, DC.

How Great Are the Costs of Offsite Damages Caused by Erosion and Runoff?

Quantifying the value of the damages caused by erosion and runoff is extremely difficult. No complete estimate is possible. Some costs are accrued or hidden; for instance, ditch clearing or dredging of waterways may be postponed for lack of funds or other reasons. However, studies completed by the Conservation Foundation estimate that the offsite costs of all water erosion in 1980 were between $3.2 billion and $13 billion, with the best single-value estimate being approximately $6 billion. 7/ Of the total, about one third, or $2.2 billion, can be attributed to erosion from cropland.

For estimating costs, the Conservation Foundation described offsite effects of erosion as instream and offstream effects. Instream effects are those caused by sediment, nutrients, and other erosion-related contaminants in streams and lakes. These contaminants affect aquatic organisms, water-based recreation, water-storage facilities, and navigation. Offstream effects are those that occur before the contaminants reach a waterway, during floods or windstorms, or after water is taken from the waterway to be used by industries, municipalities, or farms. Instream damages are estimated to be more than twice as great as offstream damages (table 37). The estimates do not include effects on the biological community because no recognized methodology exists for setting a value on the damage caused to aquatic ecosystems, aside from the effects on recreation.

The estimates of costs were derived from extrapolation of actual costs incurred in selected areas. They provide an indication of the order of magnitude and relative distribution of costs.

Table 37.--Damage costs of water erosion

Type of impact	Single-value estimate	Range of estimates
	(million 1980 dollars)	
Instream effects		
Biological impacts	not estimated	
Recreational uses	2,000	950-5,600
Water-storage facilities	690	310-1,600
Navigation	560	420- 800
Other instream uses	900	460-2,500
Subtotal--Instream (rounded)	4,200	2,100-10,000
Offstream effects		
Flood damages	770	440-1,300
Water-conveyance facilities	200	140- 300
Water-treatment facilities	100	50- 500
Other offstream uses	800	400- 920
Subtotal--Offstream (rounded)	1,900	1,100-3,100
Total effects (rounded)	6,100	3,200-13,000

Source: Clark et al. 1985

7/ Clark, Edwin H., II, Jennifer A. Haverkamp, and William Chapman. 1985. Eroding soils: The off-farm impact. The Conservation Foundation, Washington, DC.

Instream Damages

Total instream damages due to erosion are estimated to be $5.7 billion annually (table 38).

Sediment and other erosion-related pollutants can cause unfavorable conditions in receiving waters when they affect a use such as transportation or agriculture or wildlife habitat. Deposition of sediment within waterways decreases storage capacity in lakes and reservoirs, clogs streams and drainage channels, causes deterioration of aquatic habitats, and damages water distribution systems.

Recreation opportunities.--Sediment can greatly reduce the suitability of water for recreational uses. Sport fishing, swimming, and boating are directly impaired. Silt-laden water is more dangerous; a rough estimate is that about 100 drownings occur annually as a result of turbidity. For people who are picnicking or walking or playing near the water, turbidity and sedimentation diminish the quality of the recreational experience. The aggregate impact of less attractive water bodies may be very high because so many people are affected.

Water storage facilities.--Sediment reduces the storage capacity of lakes and reservoirs, changes the temperature of the water, and provides increased opportunities for the growth of water-consuming plants.

Transportation.--Sediment damages to transportation systems are manifested in costs associated with the maintenance of channels and harbors, transportation delays, accidents, operation and maintenance of equipment, and cleanout of roadside ditches. The largest damage costs to transportation are associated with the maintenance of channels and harbors for navigation. Between 1979 and 1983 the Corps of Engineers spent an average of $311 million annually (1980 dollars) dredging rivers and harbors. The Corps is responsible for dredging about half the sediment; other government agencies and private concerns remove the rest. Many of the reported dredging costs cover only the actual sediment removal and do not

include the cost of disposal. Studies by the Corps and the General Accounting Office indicate that proper sediment disposal can double or even triple dredging costs.

Other instream damages.--Other instream effects include damages to commercial fisheries and to preservation values. Erosion-related pollutants cause the same problems for commercial fisheries as for recreational fisheries. Preservation values represent the value that people place on clean water.

Offstream Damages

Offstream damages occur before sediment and associated pollutants reach a waterway, during floods, or after water is diverted from a stream for offstream use. Table 39 summarizes estimated annual offstream damages.

Flood damages.--Sediment increases the frequency and depth of flooding, primarily by aggradation of streambeds, and causes severe property damage when flood waters drop their sediment load in inhabited areas. Damages of this kind accounted for about 12 percent of the Nation's total flood damages, or about $1.0 billion in 1984.

Sediment deposited by flood waters can cause two types of damage on cropland. One is the long-term loss in yield associated with the deposition of relatively infertile material on good agricultural land. The value of this loss has not been estimated. The other loss is damage to the current crop that occurs when sediment buries growing crops or covers plants with a thin film of sediment that interferes with photosynthesis and respiration. Nationwide, the loss of production caused by sediment deposition ranges from $150 to $500 million annually.

Water conveyance systems.--Sediment can cause various problems in water conveyance facilities. Some of it settles in drainage ditches before the water reaches a waterway. Annual sediment removal and weed control in the Nation's 110,000 miles of irrigation canals is a

Table 38.--Estimated instream damages resulting from erosion

Farming region	Damage to--				Total
	Recreation 1/	Water storage	Transportation	Other	
	(millions of 1984 dollars)				
Northeast	525	34	113	185	857
Lake States	180	57	45	80	362
Corn Belt	561	57	104	71	793
Northern Plains	60	126	27	66	279
Appalachian	164	46	86	76	372
Southeast 2/	---	46	128	62	236
Delta States	64	46	157	89	356
Southern Plains	316	160	61	76	613
Mountain States	140	307	118	66	631
Pacific	547	274	76	261	1,158
Total 3/	2,557	1,153	915	1,032	5,657

1/ Includes marine fishing.
2/ Water quality problems identified in the Southeast were due primarily to pollution from point sources; this finding does not mean that the actual contribution of soil erosion is minor.
3/ The nationwide water quality data used refer only to streams, not to lakes and reservoirs.
Source: Damages estimated for the Nation by Clark et al, 1985, were assigned to farming regions according to the procedure used by Marc Ribaudo. 1986. Reducing soil erosion: Offsite benefits. AER 561. Economic Research Service, USDA, Washington, D.C.

Table 39.--Estimated offstream damages resulting from erosion

Farming region	Area affected				Total
	Flood	Water conveyance	Water treatment	Other	
	(millions of 1984 dollars)				
Northeast	97	8	24	188	317
Lake States	65	8	15	172	260
Corn Belt	102	50	10	141	303
Northern Plains	79	37	6	37	159
Appalachian	90	22	11	147	270
Southeast	83	11	6	83	183
Delta States	125	14	6	115	260
Southern Plains	88	34	19	101	242
Mountain	104	64	14	125	307
Pacific	159	89	15	85	348
Total	992	337	126	1,194	2,649

Source: Damages estimated for the Nation (Clark et al., 1985) were assigned to farming regions according to the procedure used by Ribaudo (1986).

significant cost. According to the Bureau of Reclamation, sediment removal accounts for 85 to 95 percent of the $300 million annual cost of canal maintenance, and weed control accounts for 5 to 15 percent.

Water treatment facilities.--As the turbidity of a water supply increases, so also do the investment required and the operation and maintenance costs of the water-treatment water facility. Sedimentation basins must be built, chemical coagulants added, and filters cleaned more frequently. Although most water used for industrial purposes does not need to be of high quality, much of it may nevertheless require treatment to remove suspended solids.

Other offstream damages.--Suspended solids reduce the efficiency and decrease the durability of water-using equipment, such as hydro-electric power plants and water cooling facilities, thus adding to the cost of operation. Farmers who use irrigation water containing sediment and other erosion-related contaminants may incur increased costs in addition to realizing lower yields because of dissolved salts.

Aquatic Habitat

There is no commonly accepted method of estimating the costs of the damage that erosion and runoff cause to the biological community. The absence of an overall estimate does not mean, however, that the costs are small. Sediment can cause damage to aquatic organisms directly or indirectly, as by destroying the organism's required habitat. Suspended solids can block sunlight from aquatic plants, reduce the oxygen supply in fish spawning areas, and clog smother fish eggs and cover food sources. Sediment and excess nutrients can cause turbidity, which interferes with feeding habits of fish. The reduction in sunlight reduces the population of aquatic plants, of the shellfish and other invertebrates that feed on the plants, and of the fish that feed on both.

The National Fisheries Survey, 8/ conducted by the United States Environmental Protection Agency and the United States Department of the Interior's Fish and Wildlife Service, estimated the extent of damage from all sources to aquatic habitat in rivers and streams. The survey reported that the quality of aquatic habitat is impaired for more than four-fifths of the Nation's stream fish communities. The survey did not deal with lakes or wetlands.

The major impairments of water quality for aquatic species are:

o turbidity, affecting 42 percent of perennial streams and 34 percent of all streams;

o high water temperature, affecting 28 percent of perennial streams and 26 percent of all streams;

o nutrient surpluses, affecting 16 percent and 13 percent respectively;

Table 40.--Probable sources of water quality problems affecting aquatic habitat, by stream mileage affected

Probable source	All streams Miles	All streams Percent	Perennial streams Miles	Perennial streams Percent
Total nonpoint contribution	367,244	38.4	330,840	49.6
Agricultural sources	281,241	29.5	250,637	37.6
Grazing	21,970	2.3	19,515	2.9
Natural sources	212,389	22.2	149,893	22.5
Mining (nonpoint)	31,847	3.3	30,894	4.6
Silviculture/logging	71,736	7.5	68,981	10.3
Urban runoff	40,376	4.2	38,027	5.7
Bedload movement	5,299	0.6	5,299	0.8
Roads	3,569	0.4	3,569	0.5
Total point source contribution	117,684	12.3	116,572	17.5
Municipal point sources	63,816	6.7	62,703	9.4
Feed lots	59,947	6.3	53,775	8.1
Industrial point sources	47,097	4.9	46,069	6.9
Combined sewers	29,246	3.1	29,246	4.4
Construction activity	29,110	3.1	29,110	4.4
Mining (point)	28,686	3.0	28,686	4.3
Individual sewage disposal	47,823	5.0	47,097	7.1
Other	19,445	2.0	18,524	2.8
Dam releases	19,314	2.0	19,314	2.9
Leachate from landfill	5,504	0.6	5,504	0.8

Source: Based on data collected for the National Fisheries Survey (1982).

8/ Judy, R.D., Jr., P.N. Seeley, T.M. Murray, S.C. Svirsky, M.R. Whitworth, and L.S. Ischinger. 1984. 1982 national fisheries survey. Vol. 1: Technical report: initial findings. U.S. Fish and Wildlife Service, Report no. FWS/OBS-84/06. Washington, DC.

o toxic substances, affecting 13 percent and 10 percent respectively;

o low concentrations of dissolved oxygen, affecting 11 percent and 10 percent respectively.

Nonpoint sources damage more miles of streams than point sources. Nonpoint sources contribute to water quality problems in 38 percent of all streams and cause major problems in 18 percent (table 40). Agricultural sources of pollution adversely affect 29 percent of all streams and cause major problems in 17 percent. Municipal and industrial point sources are located on (or have the potential to affect) about 20 percent of all streams; they are adversely affecting over 10 percent of streams and are causing major problems in 5 percent.

In addition to damaging water quality, erosion reduces the quality of habitat in other ways. Stream habitat conditions limit the fish community in about 49 percent of all streams. The predominant limiting factors are a lack of adult and juvenile habitat and of egg and larvae habitat. Major components of aquatic habitat, such as pools, spawning gravels, overhead cover, and riffles, are absent or impaired in many streams. The major causes of habitat problems are excessive sedimentation, water diversions, bank erosion and sloughing, and channelization. Habitat problems and water quality problems are related. Excessive sedimentation (a concern in almost 28 percent of all streams) and bank erosion (in 18 percent of all streams) are directly implicated in loss of adult, juvenile, larvae, and egg habitat. Sedimentation is largely associated with natural and agricultural sources.

Significant limiting factors also occur within the fish communities, including fish kills (15 percent of all streams) and contamination of fish flesh (9 percent of all streams). Probable sources of these problems are natural causes, pesticides, and other noxious or toxic substances.

Wind Erosion Reduces Air Quality

Wind erosion in the United States moves about 2 billion tons of soil annually. Windblown soil not only robs the land of good topsoil, it also becomes an air quality problem. Respiratory ailments of man and animals are exacerbated. Highway and air vision is impaired. Dust can permeate offices, homes, and factories. Pesticides may be carried long distances. Where dust from soil blowing settles on plant leaves it impairs the plants' ability to use sunlight in photosynthesis. When airborne dust accumulates on leafy vegetables, the quality of the crop may be seriously damaged. Larger windblown particles can damage young plants by abrasion or cut them at ground level.

Some efforts have been made to place economic values on offsite damages resulting from wind erosion. A recent study in New Mexico 9/ was based on a survey of households and businesses in the state which asked respondents to estimate how much damage, if any, they were experiencing. The answer was about $466 million annually, or the equivalent of an average $3.00 per ton of wind erosion. This estimate suggests that the offsite costs of wind erosion may be larger than had been thought, possibly even comparable to those of water erosion.

Wind erosion is a key factor in reducing visibility in the central United States; as figure 68 shows, visual range declines sharply along the north-south line of the Great Plains. In the eastern states, atmospheric sulfate outranks windblown dust as a cause of impaired visibility (compare fig. 52 for conditions in the Northeast).

9/ Huzar, Paul C., and Steven L. Piper. 1985. Offsite economic costs of wind erosion in New Mexico. Paper presented at the Symposium on Offsite Costs of Soil Erosion, Washington, D.C., May 1985.

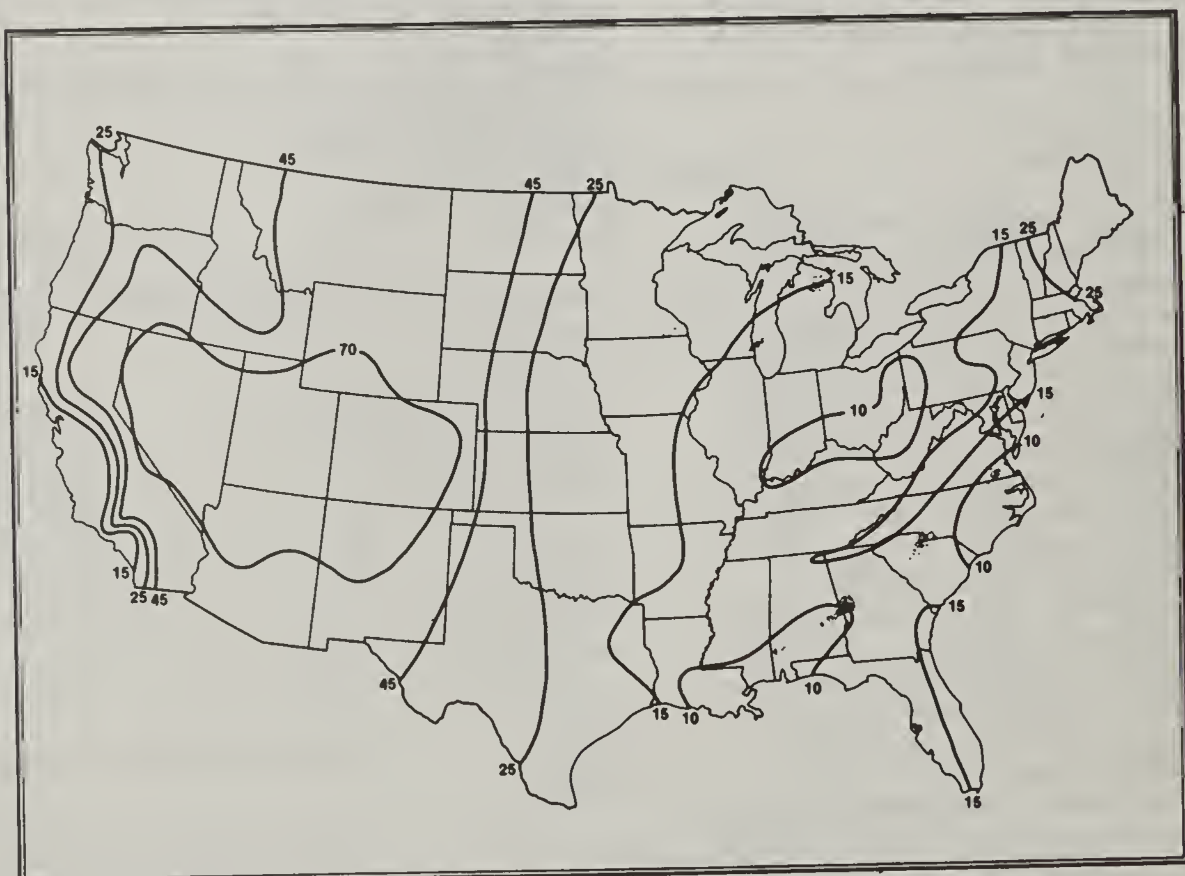


Figure 68.--Average visual range (in miles) in the contiguous United States.

STATE PROGRAMS AND LAWS ARE ADDRESSING NONPOINT SOURCE CONTAMINATION

Florida. The state has included nonpoint source pollution in its Water Quality Management Plan, and districts are establishing best management practices in the 20 top priority watershed sub-basins identified in the plan. Targeting to reduce erosion in the state's panhandle area also addresses the problem.

Idaho. Since 1981, a state cost-sharing program has helped farmers install practices to control erosion, thus reducing sediment and chemical pollution of surface waters.

Iowa. Most of Iowa's 22 million acres of corn and soybeans are treated annually with herbicides. Soil insecticides are used on half the corn acreage. An average acre of corn receives 133 lbs. of nitrogen and 60 lbs. of phosphorus. Iowa has the highest density of domestic livestock in the Nation. A project developed to help reduce the offsite costs of erosion contains a three-phase plan to (1) gather data on offsite costs for five areas of concern, (2) identify users and distribute the information gathered, and (3) assist in developing demonstration projects.

Ohio. Lake Erie receives half of all sediment deposited in the Great Lakes System. Phosphorus attached to the sediment causes eutrophication and degradation of water quality. The Lake Erie Phosphorus Reduction Task Force has determined that proper land management is the best way to reduce phosphorus transport. Demonstration projects have been set up, and water quality training is being provided to field personnel.

Pennsylvania. Livestock and poultry production have increased dramatically since 1960, resulting in increased production of animal wastes. Not only is the amount far greater than needed for crops, but when it is applied to cropland, the runoff pollutes waterways that flow into the Chesapeake Bay. A state cost-sharing program has been started in the most severely affected watershed.

South Carolina. The state administers a waste management program operating under authority of the South Carolina Pollution Control Act whereby it is unlawful for any person to allow discharge of animal waste or polluted runoff into the environment, except as in compliance with a state-issued permit.

Tennessee. The pesticide certification program of the Tennessee Department of Agriculture and the pest scouting programs of the Extension Service are helping farmers to use pesticides properly.

Utah. The state is primarily concerned with nonpoint source pollution as it affects fish and wildlife. Water that is usable by fish and wildlife is generally acceptable for other uses.

Virginia. Contamination of lakes, rivers, and streams by intensive use has mandated restrictions on specific uses for many waterways. Pollution abatement efforts are directed mainly at the Chesapeake Bay, but also at the upper Chowan River and other important watersheds. Best management practices have been installed on more than 60,000 acres.

Washington. The Puget Sound area has a unique and nationally important fisheries resource that is being threatened by sediments, animal wastes, and intensive urban activities. The Puget Sound Water Quality Authority recently was set up to develop a comprehensive plan to protect and enhance the water quality of the Sound.

STATES ARE IDENTIFYING GROUND WATER PROBLEMS AND PLANNING TO ADDRESS THEM

Connecticut. Since 1967, significant improvements have been made in the state's surface water quality. However, a mounting number of wells are found to be contaminated by agricultural chemicals; sedimentation and animal waste problems are increasing. Connecticut's resources inventory program has been used to identify sources, solutions, and costs of problems due to animal wastes and excessively eroding cropland. SCS and state officials are using such data to develop new and better approaches to problem-solving, but more data are needed.

Maine. Fifty percent of the people in the state are dependent upon ground water. During 1985, a Maine study took 60 samples from 46 ground water wells in areas known for their high production of potatoes, blueberries, sweet corn, and apples. The samples were tested for the presence of 40 chemicals. Although nitrogen levels were found to be high in many areas, less than 20 percent of the samples showed pesticide residue.

Maryland. Legislation has resulted in a plan to control agricultural nonpoint source pollution through the implementation of best management practices. The goal is to have conservation plans in place on critical farms within 5 years and on all farms within 10 years. The initiative provides for cost-sharing grants and technical personnel to implement the program.

Minnesota. Increasingly high concentrations of organic wastes are being found in domestic wells, and pesticides have been detected in ground water. The application of conservation practices to reduce erosion and runoff into surface waters may increase the rate of chemical infiltration into ground water. Work is continuing on development and improvement of predictive water quality computer models and on interagency efforts to improve water quality.

Nebraska. Nebraska has enacted legislation and implemented programs on chemigation, ground water protection, and sedimentation.

New York. Pollution from point sources has been significantly reduced, but nutrient pollution persists as a result of soil erosion and runoff of animal wastes and chemicals. Targeted activities are reducing nonpoint impacts. Agricultural chemicals also have been detected in ground water. Research on the ways in which agricultural chemicals move through particular types of soils will provide information on best management practices to prevent such infiltration. Accelerated land treatment and resource management systems also are needed.

Wisconsin. Although soil conservation is practiced extensively, agricultural chemicals and animal wastes from dairy farms are a serious threat to the state's waters. Ground water in some sections contains agricultural chemicals at levels that pose a hazard to human health. Wisconsin has an active program in nonpoint source identification and treatment.

CHAPTER 10
Wildlife Habitat Has Been Altered

When we use our agricultural lands, we change the quantity and quality of the habitat the land provides for wildlife and, therefore, the number and types of animals that can live there. USDA has developed a system for expressing changes in habitat in numerical form so that it is easy to compare the results of alternative actions. This system rates the diversity of the structure of the habitat as compared to that of the natural vegetation of the site. The lower the index, the less the current vegetation resembles that growing on the site before people began to use it. The structure of the habitat has been changed to the greatest degree in the regions where the land is used most intensively. The value of vegetation as habitat is affected by, and therefore can be improved by, the management practices that farmers apply.

No single federal or state agency has the sole responsibility for fish and wildlife management. State fish and wildlife agencies have the primary responsibility for managing populations of fish and wildlife on all lands within their respective states and fish and wildlife habitat on state-owned waters and lands. Federal land management agencies, such as the Fish and Wildlife Service, Forest Service, Bureau of Land Management and others, have responsibilities of managing fish and wildlife habitat on the lands that they manage, and may assist states in the management of populations on these and other lands. Other federal agencies, such as Soil Conservation Service and Cooperative Extension Service, provide technical assistance and information and education for fish and wildlife management to private landowners and landusers.

Terrestrial Habitat

The Nation's agricultural lands provide habitat for many species of wildlife. The acreage of such land that is managed primarily for wildlife, however, is small. On most agricultural land, wildlife is a secondary use. The management of the land for its primary use can enhance or degrade the quality of habitat the land provides.

For this appraisal, USDA analyzed existing data to determine the diversity and quality of the habitat that agricultural lands provide for wildlife. This analysis does not evaluate the quality of habitat for a particular species nor can it be used to predict the population of a given species in a specific area. Rather, it provides a relative measure of the kinds and extent of habitat available in an area. The data for the analysis can be used to estimate effects that changes in land use might have.

The appraisal method is based on the assumption that wildlife species occupy specific parts of the habitat--breeding and feeding niches--and that the greater the diversity of the niches available, the greater the diversity of wildlife. 1/ Table 41 shows niches occupied by some common species.

Table 41.--Wildlife species and groups: feeding and breeding habitat

	Feeding							Breeding						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Canvasback	1	2							2					
Snapping turtle	1	2								3	4			
Eastern painted turtle		2	3								4			
American coot		2	3						2					
Beaver		2	3	4	5				2	3				
Muskrat		2		4					2	3				
Blue-winged teal		2		4					2		4			
Wood duck		2		4									6	
Plains pocket gopher			3	4						3	4			
Badger			3	4						3	4			
Coyote			3	4	5					3				
Grasshopper sparrow				4							4			
Meadowlark				4							4			
White-tailed jackrabbit				4							4			
Canada goose				4							4			
Pintail				4							4			
Red-winged blackbird				4							4			
Mallard				4							4			
California quail				4							4			
Hungarian partridge				4							4			
Kestrel				4									6	
Mourning dove				4							4	5		7
Horned lark				4							4			
Woodcock				4							4			
Prairie dog				4						3				
Scaled quail				4							4			
Greater prairie chicken				4							4			
Ring-necked pheasant				4	5						4			
Eastern cottontail				4	5						4			
Bobwhite				4	5						4			
Gray fox				4	5					3	4			
Clay-colored sparrow				4	5						4			
White-tailed deer				4	5						4			
Elk				4	5						4	5		
Mule deer				4	5						4			
Antelope				4	5						4			
Sage grouse				4	5						4			
Sharp-tailed grouse				4	5						4			
Black-capped chickadee				4	5	6	7						6	
White-breasted nuthatch				4	5	6	7						6	
Red-bellied woodpecker				4	5	6							6	
Eastern fox squirrel				4	5		7						6	7
Blue jay				4	5		7							7
Eastern wild turkey				4	5		7				4			
Ruffed grouse				4	5		7				4			
Raccoon				4	5		7			3	4		6	
Hairy woodpecker					5	6							6	
Northern oriole							7							7

1 = water column
2 = water surface (wetlands)
3 = subsurface
4 = understory
5 = midstory
6 = tree bole
7 = tree canopy

1/ Short, H.L., and K.P. Burnham, 1982. Technique for structuring wildlife guilds to evaluate impacts on wildlife communities. U.S. Fish and Wildlife Service, Special Science Report-Wildlife 244.

Short, H.L.. and S.C. Williamson. 1985. Evaluating the structure of habitat for wildlife. U.S. Fish and Wildlife Service. Mimeograph, Western Energy and Land Use Team, Fort Collins, Colorado.

Changes in Habitat: How Extensive?

When we use our agricultural lands, we change the quantity and quality of the habitat the land provides for wildlife and, therefore, the number and types of animals that can live there.

Figure 69 shows the degree to which human activity has changed the habitat available on nonfederal lands in each land resource region. The figure shows the "habitat structure" in 1982 as a percentage of the structure present in each land resource region when the region retained its potential natural vegetation --that is, before the region had been extensively changed by human action. Habitat structure is a rating of the diversity of the vegetation. Land resource regions are broad areas of generally similar climate and land and are characterized by similar patterns of use.

As the figure shows, the diversity of the vegetation has been greatly reduced in many regions. Diversity has been most reduced in the central and upper Midwest (index of 0.29), where the habitat character has been changed from primarily forest and prairie to mixtures of cropland, pasture, and woodlots. It has been changed least in the Appalachian region (index of 0.86). In general, about half the land resource regions have a moderate degree of habitat diversity, and six of them retain at least two-thirds of the diversity of the natural vegetation.

HABITAT STRUCTURE: Spaces for Species

Habitat can be described as a structure--a series of layers, each of which occupies a distinct volume of space and supports a specific type of vegetation.

Some habitats contain more layers than others, thus accommodating more wildlife species. Habitats can be evaluated and compared on the basis of the diversity of their structure--the number of habitat layers present and the extent and distribution of each habitat layer.

Table 42.--Habitat structure index, by land resource region

Symbol and name		Habitat structure index
A	Northwestern Forest, Forage, and Specialty Crop Region	0.66
B	Northwestern Wheat and Range Region	.59
C	California Subtropical Fruit, Truck, and Specialty Crop Region	.64
D	Western Range and Irrigated Region	.66
E	Rocky Mountain Range and Forest Region	.77
F	Northern Great Plains Spring Wheat Region	.58
G	Western Great Plains Range and Irrigated Region	.81
H	Central Great Plains Winter Wheat and Range Region	.63
I	Southwest Plateaus and Plains Range and Cotton Region	.52
J	Southwestern Prairies Cotton and Forage Region	.49
K	Northern Lake States Forest and Forage Region	.55
L	Lake States Fruit, Truck, and Dairy Region	.29
M	Central Feed Grains and Livestock Region	.29
N	East and Central Farming and Forest Region	.86
O	Mississippi Delta Cotton and Feed Grains Region	.34
P	South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region	.59
R	Northeastern Forage and Forest Region	.65
S	Northern Atlantic Slope Diversified Farming Region	.51
T	Atlantic and Gulf Coast Lowland Forest and Crop Region	.68
U	Florida Subtropical Fruit, Truck Crop, and Range Region	.51

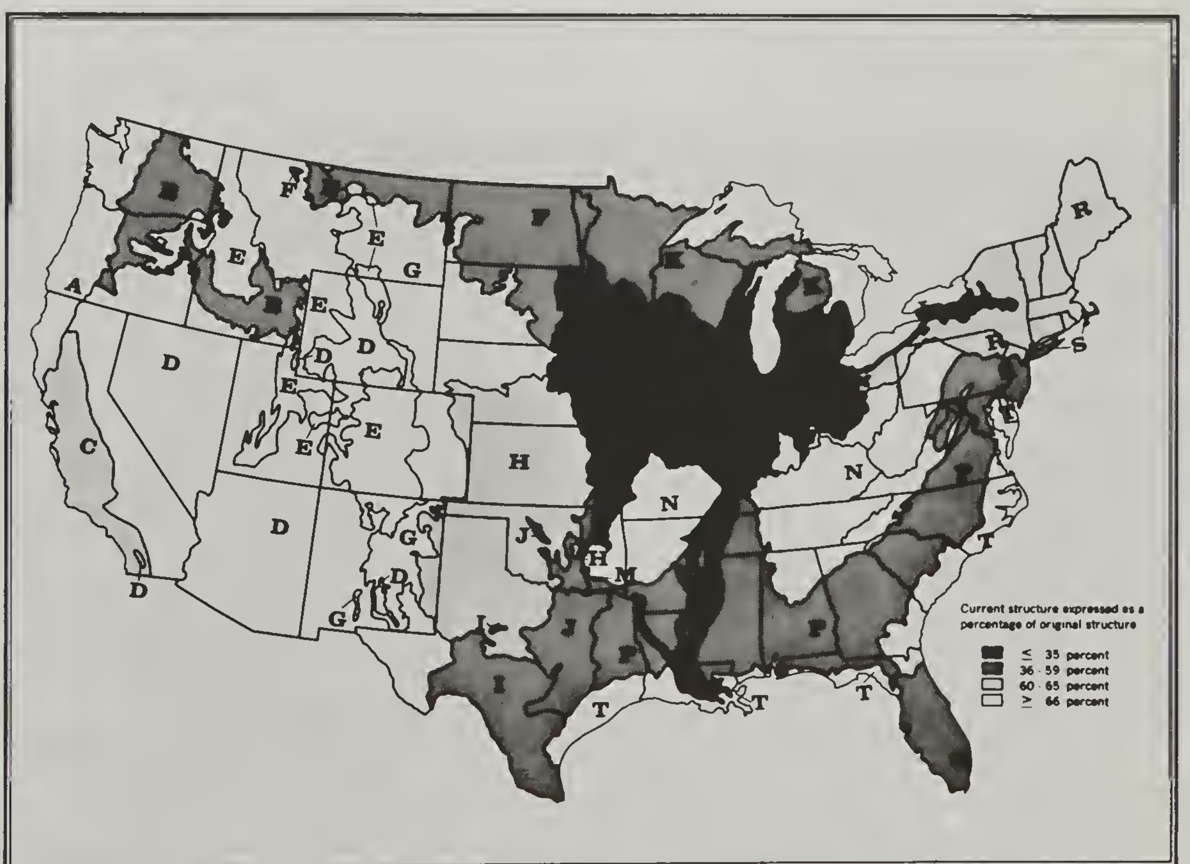


Figure 69.--Habitat structure index, by land resource region.

In this report, the maximum number of layers that the habitat may contain is seven. These are: the water, the surface of wetland or shallow water areas, the subsurface, the surface vegetation or understory, the midstory vegetation or shrub layer, the tree boles, and the tree canopy (fig. 70 and table 43). 2/

HABITAT LAYER VALUE:
Management Matters

Information about the extent of the various layers can be used to estimate how much of an area can provide habitat for the kinds of wildlife that use those layers.

Each acre of a given habitat layer, however, does not necessarily provide habitat of equal quality and would not necessarily support the same number of wildlife. The way that farmers and ranchers manage their land affects the quality of the habitat available in the layer. These effects of management must be considered in assessing the habitat provided by an area.

Table 44 shows, for each land resource region in the conterminous states, the adjusted acreage of each layer as a percentage of the total area. The extent of each layer was estimated by multiplying the acreage of land in each major agricultural use, as reported in the 1982 NRI, by factors that account for the effects of certain management actions (table 45).

Table 43.--Criteria defining habitat layers

Layer		Criteria
1	Water column	Water layer between the surface of a water body and the bottom (usually 6 or more feet deep).
2	Water surface (wetland)	Land surface-water interface classified as wetland (water depth usually less than 6 feet).
3	Terrestrial subsurface	Extends downward from 4 inches below the apparent surface.
4	Understory (terrestrial surface)	Extends from 4 inches below the apparent surface up to 20 inches above the apparent surface and provides at least 5 percent cover when projected to the surface (2,200 ft^2/acre).
5	Shrub midstory	Vegetation at a height of 20 inches up to 25 ft that provides at least 5 percent cover when projected to the surface (2,200 ft^2/acre).
6	Tree bole	Tree trunks having a diameter at breast height of at least 8 inches and a stand density of at least 5 per acre.
7	Tree canopy	Vegetation structure 25 ft or more above the terrestrial or aquatic surface, that provides at least 5 percent cover when projected to the surface (2,200 ft^2/acre).

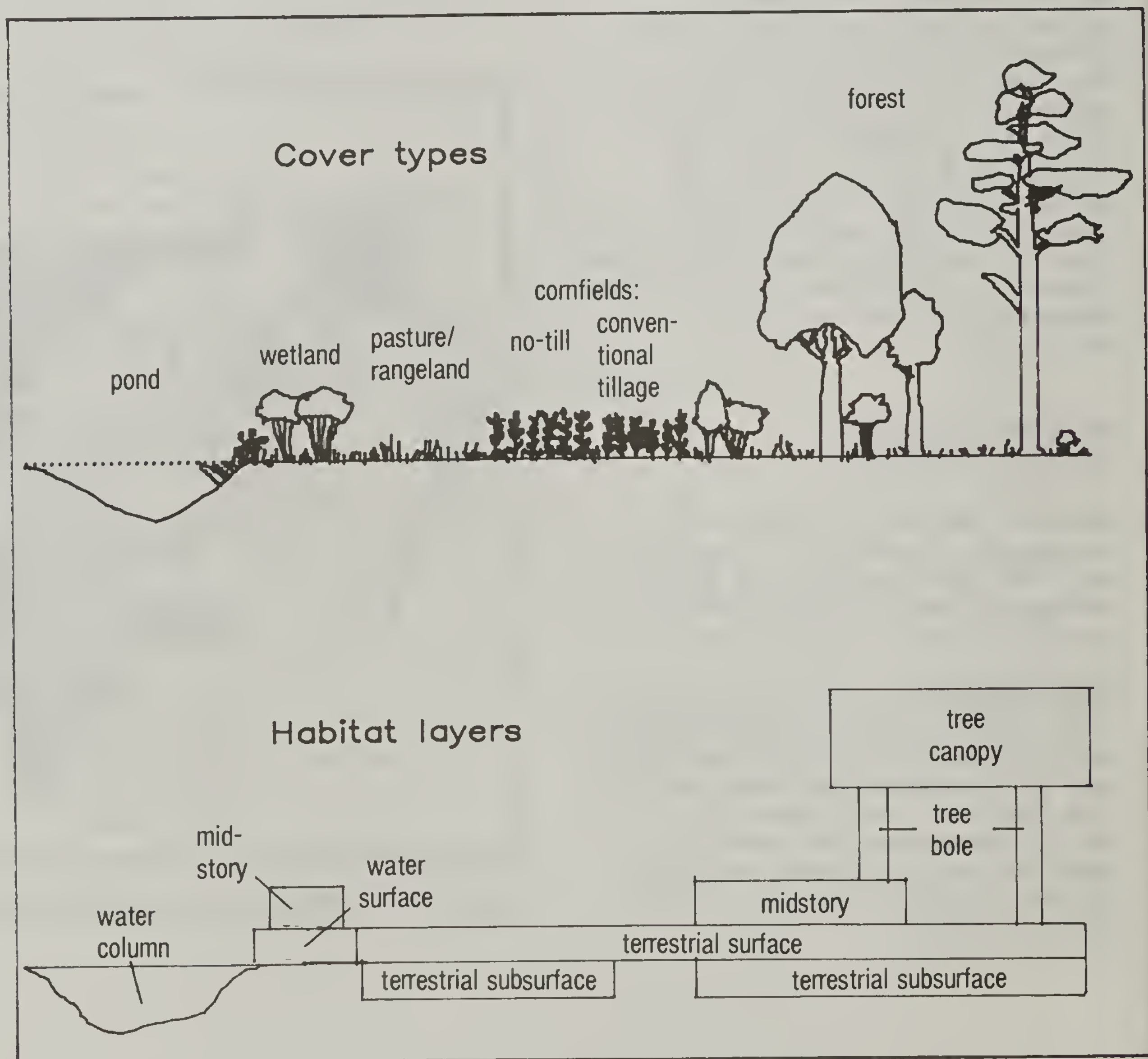


Figure 70.--Cover types and habitat layers.

2/ Streeter, R.G., D.E. Chalk, C.H. Thomas, and W.B. Krohn. 1983. National appraisal for wildlife habitat--from inventory to management. Proceedings of the International Conference on Renewable Resource Inventories for Monitoring Changes and Trends. Corvallis, Oregon.

The factors in table 45 are based on the following assumptions about the general effects of agricultural practices on wildlife habitat.

o Draining wetlands reduces habitat diversity.

o Leaving winter cover, especially residue over 7 inches in height, on croplands improves habitat.

o Improving range condition improves habitat.

o Permitting dense brush to invade grasslands reduces habitat. So does completely clearing brush.

o Allowing livestock to graze the understory vegetation in forests reduces habitat.

o Clearcutting, which eliminates large trees needed by many species that use the tree bole layer, reduces habitat.

o Monoculture, which reduces the interspersion of cover types, reduces habitat.

Table 44.--Habitat layer values

Land resource region	Habitat layer value*						
	1	2	3	4	5	6	7
A	0.04	0.02	0.92	0.32	0.57	0.46	0.77
B	.02	.01	.74	.76	.21	.08	.14
C	.03	.02	.78	.70	.09	.09	.24
D	.03	.02	.94	.75	.32	.06	.10
E	.03	.02	.94	.71	.28	.19	.32
F	.02	.04	.57	.86	.01	.00	.01
G	.01	.01	.91	.90	.10	.01	.03
H	.01	.00	.77	.86	.14	.00	.01
I	.01	.00	.93	.83	.52	.00	.00
J	.03	.01	.85	.82	.19	.02	.05
K	.08	.15	.82	.47	.31	.25	.63
L	.04	.07	.54	.51	.15	.10	.24
M	.02	.01	.47	.62	.08	.06	.09
N	.03	.01	.90	.44	.46	.32	.57
O	.07	.14	.45	.56	.16	.19	.23
P	.03	.09	.81	.42	.45	.32	.61
R	.06	.06	.89	.28	.56	.39	.72
S	.05	.04	.81	.42	.42	.26	.51
T	.16	.20	.67	.35	.38	.22	.47
U	.16	.17	.78	.58	.22	.11	.30

*Percentage of area that provides habitat layer.

1 = water column
2 = water surface (wetlands)
3 = subsurface
4 = understory
5 = midstory
6 = tree bole
7 = tree canopy

White-tailed fawn on the alert at edge of woody cover. The diversity of such transition areas between different plant communities makes them prime habitat for many kinds of wildlife.

Table 45.--Quality factors affecting habitat value

Land use/cover type	Habitat layer	Quality factor
Fruit, nuts, and other horticulture	Water surface	1.00 if wetland 0.00 if not wetland
	Subsurface	1.00
	Terrestrial surface	1.00
	Midstory	0.00
	Tree canopy	1.00
Row crops, small grains, and vegetables	Water surface	1.00 if wetland 0.00 if not wetland
	Terrestrial subsurface	1.00 if conservation tillage 0.00 if not
	Terrestrial surface	0.33 if winter cover height is 6" or less 0.66 if winter cover is 7" to 12" 1.00 if winter cover is more than 12"
Grass/hay	Water surface	1.00 if wetland 0.00 if not wetland
	Subsurface	1.00
	Surface	0.75 because cut for hay
Grass/pasture	Water surface	1.00 if wetland 0.00 if not wetland
	Subsurface	1.00
	Surface	1.00 if good condition 0.90 if fair condition 0.80 if poor condition
	Midstory	1.00 if woody canopy is 10-55 percent 0.33 if woody canopy is more than 55 percent 0.00 if woody canopy is less than 10 percent
Rangeland	Water surface	1.00 if wetland 0.00 if not wetland
	Subsurface	1.00
	Surface	1.00 if good to excellent condition 0.90 if fair condition 0.80 if poor condition
	Midstory	1.00 if woody canopy is 10-55 percent 0.33 if woody canopy is more than 55 percent 0.00 if woody canopy is less than 10 percent
Forest	Water surface	1.00 if wetland 0.00 if not wetland
	Subsurface	1.00 if not wetland 0.00 if other
	Surface	1.00 if understory is grass-forbs and is not grazed 0.66 if understory is grass-forbs and is grazed
	Midstory	1.00 if understory is woody vegetation 0.66 if understory is woody and is grazed
	Tree bole	1.00 if diameter at breast height is 12" or more 0.80 if diameter at breast height is between 8"-12" 0.00 if diameter at breast height is less than 8"
	Tree canopy	1.00 0.45 if forest is low productivity type

For each land use, the percentage of the acres located within one-fourth mile and within one-half mile of land in other uses or of water areas is recorded.

Although most of the Nation's streams provide habitat for some aquatic species (table 46), the National Fisheries Survey 3/ indicated that 81 percent of the Nation's fish communities are adversely affected by limiting factors (table 47). Limiting factors may result from either natural conditions or human activity.

The state fishery biologists who provided information for the National Fisheries Survey surmised that, without control of problems that stem from human actions, a dramatic decrease in the Nation's fish communities could occur in streams where present capabilities are marginal. The number of higher ranked streams could decline, and the number of streams that cannot support fish and of streams that have only minimal ability to support sport fish could increase.

At the time of the survey, about 46 percent of the Nation's streams were rated at least fair in terms of their ability to support sport fish populations, which generally are intolerant of adverse aquatic conditions. About 21 percent had marginal capability to support sport fish. About one-third were rated poor in suitability for sport fish, that is, they were not able to support these species. Many of these latter streams are intermittent and have little potential for improvement. The ability of the Nation's streams to support sport fish had not changed appreciably during the 5 years preceding the survey. Overall, capability was unchanged in 91 percent, improved in 4 percent, and reduced in 5 percent of all streams.

Table 46.--Streams that provide habitat for fish, by fish class, estimated miles and percentage

Fish class	All streams		Perennial streams	
	(miles)	(percent)	(miles)	(percent)
All sport fish	701,780	72.6	636,260	95.5
Anadromous sport fish	102,145	10.6	100,216	15.
Commercial fish	163,005	16.9	153,377	23.0
All nonsport fish	657,606	68.1	582,895	87.4
Anadromous nonsport fish	20,198	2.1	19,540	2.9
Threatened/endangered species	7,720	0.8	7,720	1.2
Species of special concern	23,204	2.4	21,450	3.2
No fish	204,074	21.1	18,298	2.7

Based on data collected for the National Fisheries Survey (1982).

Table 47.--Streams where problems adversely affect fisheries, estimated miles and percentage

	All streams		Perennial streams	
	(miles)	(percent)	(miles)	(percent)
Water quality 1/	535,084	56.0	433,987	65.1
Water quantity	649,102	68.0	387,874	58.2
Usable habitat 1/	464,885	48.7	387,024	58.1
Fish community 1/	309,630	32.4	261,018	39.2
Total adversely affected 2/	773,330	81.0	508,332	76.3

1/ The percentages for "all streams" are lower than those for "perennial streams" because intermittent streams are included in the former category; intermittent flow restricts fish habitat so severely that it can preclude effects of other factors.

2/ More than one limiting factor can operate in a particular reach.

Source: Based on data collected for the National Fisheries Survey (1982).

3/ Judy, R.D., Jr., P.N. Seeley, T.M. Murray, S.C. Svirsky, M.R. Whitmore, and L.S. Ischinger. 1984. 1982 National Fisheries Survey, Vol. I. Technical report: Initial findings. 140 pp. U.S. Fish and Wildlife Service, FWS/OBS-84/06.

Limiting Factors

Inadequate water supplies adversely affect the fish community in 68 percent of all streams and 58 percent of perennial streams (table 47). Major water quantity problems include:

- o below-optimum flows, occurring in 32 percent of streams;
- o low flows, occurring in 23 percent of streams;
- o excessive fluctuations in flow, occurring in 17 percent of streams.

Natural conditions are the most common cause of these problems; they affect flow in half of all streams. Agricultural diversions adversely affect flow in 14 percent of all streams.

Water quality problems adversely affect the fish community in 56 percent of all streams. The major water quality impairments that affect aquatic species are turbidity, high water temperature, nutrient surpluses, toxic substances, and low concentrations of dissolved oxygen. Nonpoint sources of contamination damage more miles of streams than do point sources. 4/

Stream habitat conditions limit the fish community in about 49 percent of all streams. The major limiting factors are a lack of adult and juvenile habitat and of egg and larvae habitat.

4/ The effects of water quality problems on aquatic habitat are also discussed in chapter 9.

Distribution of Fish

Table 10-11 shows the stream miles that are inhabited by sport fish species, fish species federally designated as threatened and endangered, and fish species designated as of special interest by state governments.

Sport fish species are widely distributed. At least one species of sport fish is present in 73 percent of all stream miles.

Nonsport fish species are somewhat less widespread than sport fish species but tend to be more abundant where they occur. Commercial fish species occur in 17 percent of all streams.

Turbidity impairs aquatic habitat. The foreground river is turbid with silt after a recent rain while the stream it flows into is clear.

The most widespread sport fish species are largemouth bass and rainbow trout. Largemouth bass inhabit 27 percent of all streams and rainbow trout inhabit 22 percent. They are typical respectively of the warm-water and cold-water fish communities. Both species occupy the top of the aquatic food chain and are intolerant of poor water quality. Their wide distribution may result in part from past intensive stocking in an effort to extend their ranges, but it also suggests that conditions in most perennial streams are generally suitable for fish communities.

The common carp, an introduced species, is the most prevalent nonsport fish, occurring in 19 percent of all streams. The native green sunfish, which ranks as both a sport and nonsport fish in different states, is second only to the largemouth bass in distribution, occurring in over 25 percent of all streams.

Less than 1 percent of all waters contain species that have been federally designated as threatened or endangered, and 2.4 percent contain state-listed species of special concern.

Twenty-one percent of all streams contain no fish. Most of these reaches are dry during some part of the year.

Most of the streams that contain fish are used throughout the year, for spawning and hatching, as nursery habitat, and for overwintering. Twelve percent of all streams serve as migration routes.

Riffles and broken shade provide good habitat for fish in a snowfed western stream.

RECOGNITION OF WILDLIFE VALUES HEIGHTENS INTEREST IN CONSERVATION EFFORTS

Illinois. Farmland-associated wildlife populations have fallen steadily since the mid-1950's as fields have become larger and agricultural practices more intensive. Birds and wildlife that inhabit the forest interior have declined as forests have become fragmented and total woodland acreage has decreased. Sedimentation and nonpoint pollution have degraded water quality in the state, reducing numbers of wetland plants, fish, and waterfowl.

Iowa. Agricultural land use changes, such as larger fields and a fairly restricted variety of crops, have had dramatic effects on Iowa's fish and wildlife populations. Some of the highest ring-necked pheasant population levels were recorded during the Conservation Reserve Program of the late 1950's and early 1960's, when almost two million birds were harvested annually. In 1985 less than one million birds were harvested--a direct result of land use changes that affected this ground-nesting bird.

Missouri. Areas that have experienced the most excessive erosion also have undergone the most severe losses in upland wildlife habitat. Using Missouri's newly developed wildlife habitat appraisal guide to evaluate current conditions and monitor changes, SCS field staff and state biologists have worked with landowners to improve wildlife habitat on 300,000 acres targeted for conservation treatment. Preliminary results are highly positive.

New Hampshire. The state is attempting to reestablish the wild turkey and to increase the deer population. Turkey habitat encompasses both woodland and cropland, and both need improvement for the turkey population to succeed. SCS is working with state agencies and landowners to establish winter food and shelter plantings. Increased timber harvesting has destroyed deer areas and reduced deer populations. Habitat for other kinds of wildlife also is disappearing as cropland is converted to other uses. The New Hampshire Fish and Game Department is inventorying deeryards in an effort to increase the number of deer from the present 13,000 to an optimum 40,000.

New Jersey. Fee hunting and leasing are becoming increasingly important as a source of income to farmers. Farmers need help in developing resource management systems that emphasize wildlife management practices along with other conservation practices.

Vermont. Eighty percent of the state is forested, but much of the forest is even-aged stands of timber that provide little habitat diversity. Current farming practices emphasize maximum crop production and economic return and minimize wildlife habitat. SCS is working with the state and private landowners to create more white-tailed deer habitat on private lands.

Wyoming. Overgrazing of riparian zones by livestock is the most serious threat to fish and wildlife habitat in Wyoming. Wyoming's water law does not recognize fish and wildlife as a beneficial use of water, and no legislation exists to protect riparian areas. Nevertheless, protection of riparian areas in the arid West has extremely beneficial effects in terms of reduced erosion and sediment delivery and improved forage production, fish and wildlife resources, esthetic quality, water quality, and ground water resources.

CHAPTER 11
Wetlands Have Been Lost

Wetlands are a productive and invaluable public resource. In the past, extensive acreages of wetlands have been converted to other uses, with attendant loss of wetland values. Conversion continued in spite of federal and state restrictions and regulations. Such conversion is continuing, although at a slower rate. The wetlands conservation provisions of the Food Security Act of 1985 are designed to discourage conversion for agricultural use.

"Wetlands" are lands transitional between terrestrial and aquatic systems where the water table is generally at or near the surface or where the land is covered with shallow water. Because wetlands include many diverse environments and because wetlands definitions and classification systems are needed for diverse purposes, a number of wetland classification systems have been developed. Data are shown in this chapter according to the system used by the U.S. Department of the Interior's Fish and Wildlife Service. 1/ Data are shown in appendix tables 45 through 47 according to the older Circular 39 system. 2/

Natural wetland on Maryland's Eastern Shore.

Wildlife pond in South Dakota, formed by a county road impounding water in a drainageway.

1/ Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service. Biological services program; FWS/OBS 79/31. Washington, D.C.

2/ Shaw, Samuel P., and C. Gordon Fredine. 1956. Wetlands of the United States. U.S. Department of Interior, Fish and Wildlife Service, Circular 39.

There are 90 to 100 million acres of wetlands in the United States. An estimated 12.5 million acres are in federal ownership and control and the rest are nonfederal wetlands; most of the latter--65.3 million acres, or about 86 percent--are privately owned. State governments own about 13 percent of nonfederal wetlands.

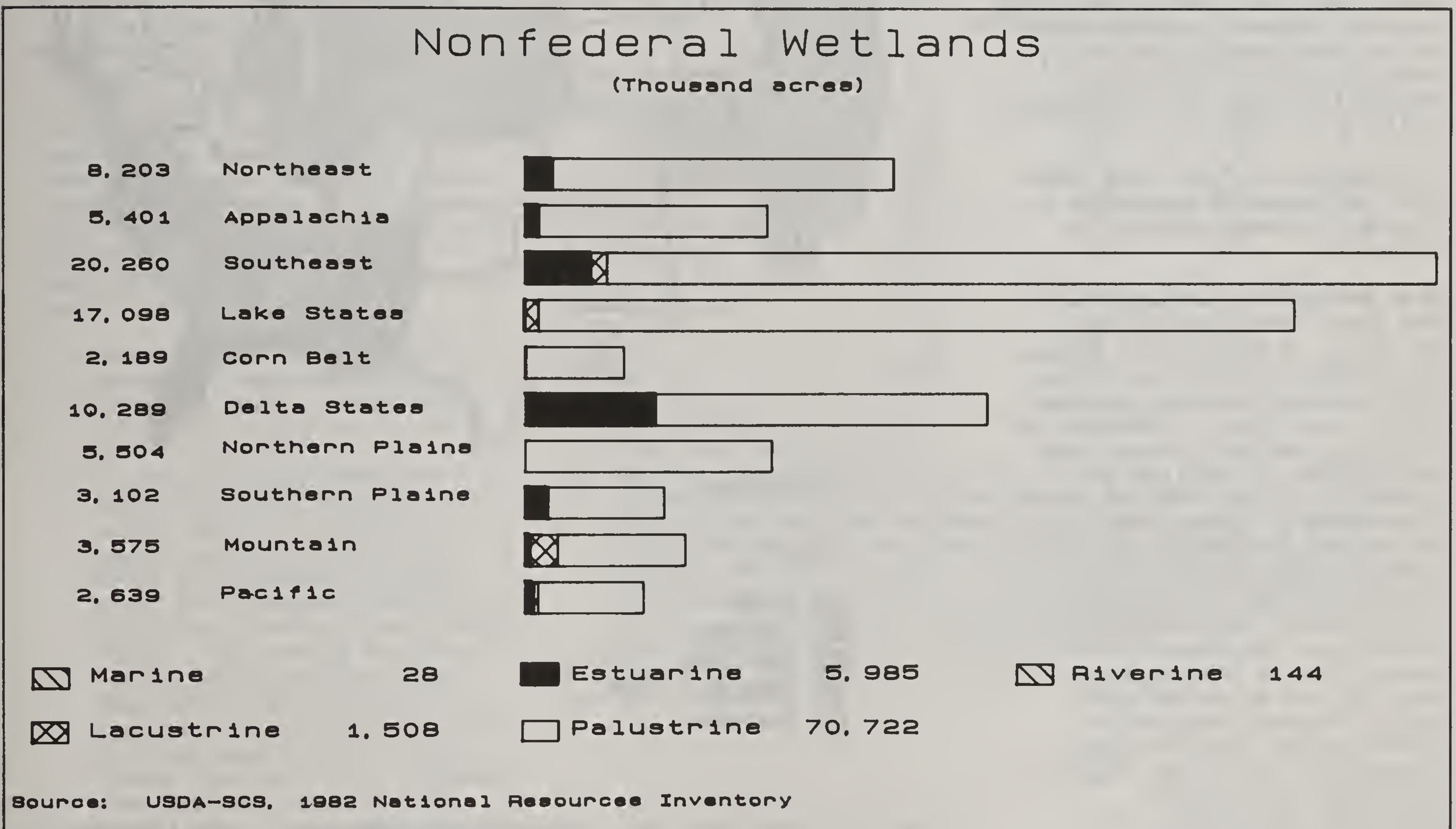


Figure 71.--Acreage of nonfederal wetlands. For state data, see appendix table 44.

The **Marine system** consists of the open ocean overlying the continental shelf and the associated high-energy coastline. Shallow bays without significant freshwater inflow and coasts with exposed rocky islands that provide the mainland little shelter from wind and waves are also considered Marine systems.

The **Estuarine system** consists of deepwater tidal habitats and adjacent tidal wetlands that are generally semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land.

The **Riverine system** includes all wetlands and deepwater habitats contained within a channel, except wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and habitats with water containing ocean-derived salts in excess of 0.5 ‰.

The **Lacustrine system** includes wetlands and deepwater habitats that are situated in a depression or dammed river channel; do not have more than 30 percent of their area covered with trees, shrubs, persistent emergents, emergent mosses or lichens; and have a total area greater than 20 acres. Similar habitats of less than 20 acres are also included if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 6.6 feet at low water.

The **Palustrine system** includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands in tidal areas where salinity due to ocean-derived salts is below 0.5‰. It also includes wetlands that are not dominated by such vegetation but are less than 20 acres, do not have active wave-formed or bedrock shoreline features, have a water depth in the deepest part of the basin of less than 6.6 feet at low water, and have salinity due to ocean-derived salts less than 0.5‰.

Wetlands are a productive and invaluable public resource. Wetlands constitute habitat crucial to many forms of wildlife. Wetlands are also important in maintaining ground water supplies and water quality; protecting shorelines from erosion; modifying climatic extremes; storing floodwaters; and trapping sediments, which can pollute waterways, smother fish eggs, and contaminate shellfish.

Wetlands vary in type from permafrost in Alaska to everglades in Florida to desert wetlands in Arizona.

Large acreages of wetlands have been lost.--Much, perhaps more than half, of the wetland acreage in existence at the time of the first European settlers has been lost to other uses. Estimates of historical wetland acreages vary widely--from 127 million to 215 million acres. The net loss of wetlands to agricultural uses between the mid-1950's and the mid-1970's was over 11 million acres--an annual loss of about 550,000 acres. More recently the rate of loss has slowed: the present rate of conversion is about 300,000 acres per year. Loss of wetlands between the mid-1950's and mid-1970's was concentrated to a large degree in the Southeast and Lower Mississippi Delta (fig. 72). The largest losses occurred in Louisiana and Mississippi, with more than 1.7 million acres each; Arkansas lost more than 1.4 million acres. Wetland losses in the North Carolina pocosin area and in Minnesota's prairie pothole region were also substantial: over 500,000 acres lost in each.

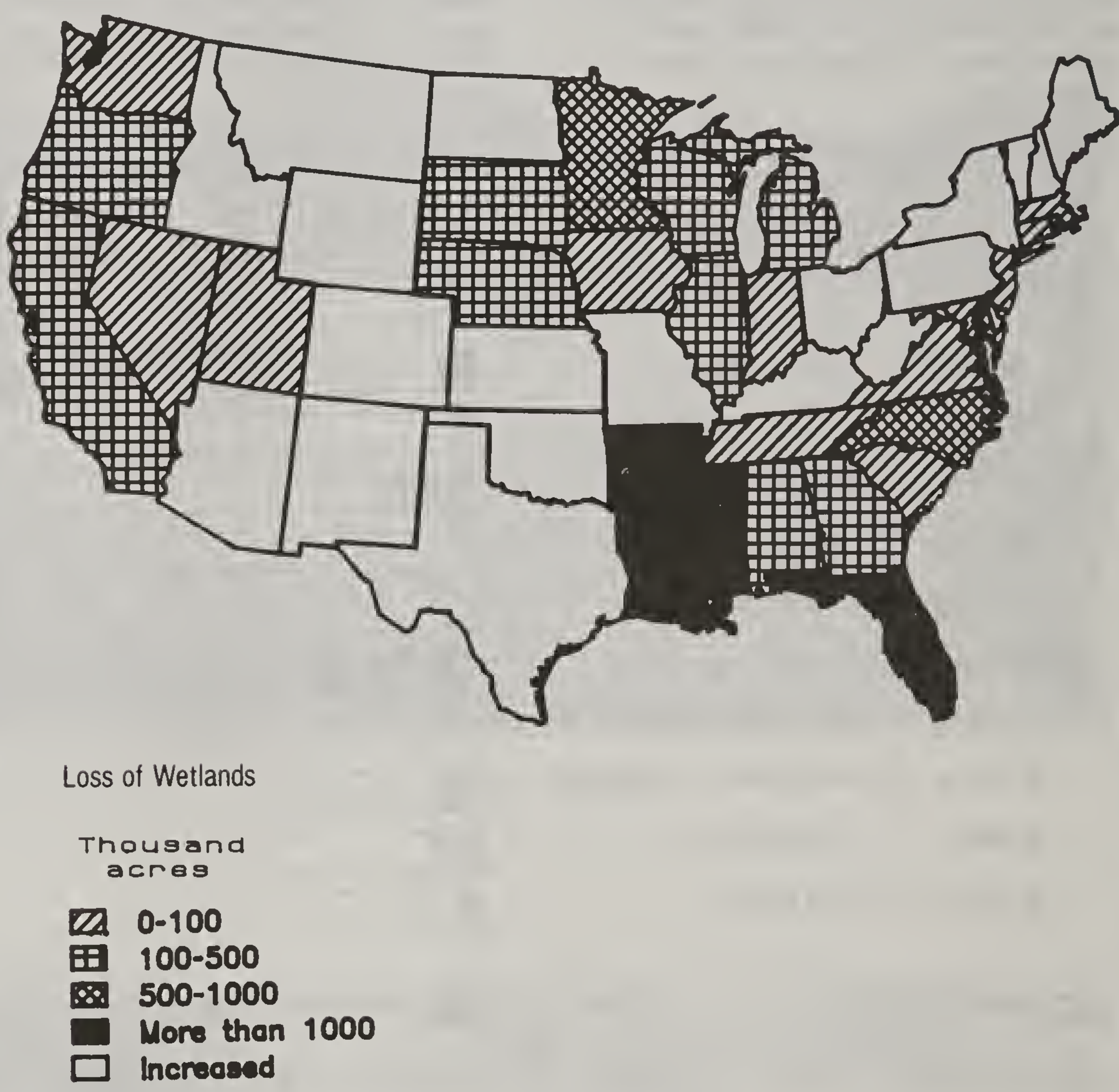


Figure 72.--Wetlands loss, mid-1950's to mid-1970's. Heimlich, Ralph E., and Linda A. Langner. 1986. Swampbusting: wetland conversion and farm programs. Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report 551, Washington, D.C.

Canada geese rest and nest each year on this pond in Massachusetts.

Remaining wetlands need protection.--The primary cause of wetland loss has been conversion to agricultural uses (table 48). Nearly half of the remaining nonfederal wetlands, including almost all the palustrine wetlands, are potentially subject to conversion for agriculture, according to the 1982 NRI. About 5.2 million acres of wetlands have high or medium potential for conversion. "High potential for conversion" means that similar lands were being converted in the years preceding the inventory. The wetland areas most likely to be drained and converted to agricultural uses are in two general categories:

- small wetland areas, either natural or man-induced, that interfere with a farmer's agricultural operation; and
- relatively large areas presently in mature hardwood stands where the value of the timber helps to offset the costs of clearing the land, where land drainage and shaping costs are relatively low, where outlets are readily available for the drainage water, and where continued profitable ownership of the land requires the development of an annual income from the land. Although some wetlands have been converted directly to agricultural uses, about half were originally forested and may have entered agricultural use after being cut over for timber.

Some tax laws (authorizing tax credits for investment, deductions for expenses, and special provisions for resource depletion) still reduce the costs of converting wetlands. Many state and local property tax codes tend to discourage preservation of wetlands by private owners. However, "Swampbuster" provisions in the Food Security Act of 1985 (Public Law 99-447), which restrict or prohibit federal commodity payments and loans to farmers who produce crops on newly converted wetlands, are designed to discourage the conversion of wetlands to agricultural uses.

Table 48.--Sources and uses of converted wetlands, United States, mid-1950's to mid-1970's

Wetland type 1/	Use of land converted: Agriculture	Urban	Other	Total
	(million acres)			
Palustrine:				
Vegetated:				
Forested	6.2	0.4	0.2	6.8
Emergent	4.6	0.4	0.3	5.3
Scrub/shrub	1.0	0.1	*	1.1
Subtotal	11.7	0.9	0.6	13.3
Non-vegetated	0.1	*	0.1	0.2
Subtotal	11.8	1.0	0.7	13.5
Lacustrine	0.1	*	*	0.2
Estuarine	*	0.2	*	0.2
Marine	0	*	*	*
Total 2/	12.0	1.2	0.7	13.8

* = less than 100,000 acres.
1/ Wetland types are described in: Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C.; and Frayer, W.E., et al. 1985. Status and trends of wetlands and deepwater habitats in the coterminous United States, 1950's to 1970's. Department of Forestry and Wood Sciences, Colorado State University, Fort Collins, Colorado.
2/ Totals may not add due to rounding.
Source: Frayer et al.

EFFORTS TO PROTECT WETLANDS ARE INCREASING IN MANY AREAS

Connecticut. Development is causing displacement of wildlife and loss of valuable habitat. Public awareness of the value of wetlands has increased. Wetlands have been mapped statewide by type. A method for evaluating 13 inland wetland functions has been developed for citizens and public officials to use in analyzing wildlife trends and formulating policy. The information provided by the evaluations also can be helpful in addressing such concerns as water conservation and drainage.

Louisiana. Conversion of forested wetlands and associated habitats to cropland has become a major resource concern in Louisiana; 527,000 acres of land in capability classes IVw and Vw have been converted to cropland. Current legislation and policy mandate that positive steps be taken to restore these wetlands to uses and cover consistent with their capabilities.

New Hampshire. About 400,000 acres of wetlands exist in the state. Those in rapid growth areas are under increasing pressure for conversion to urban uses. Local ordinances now protect about 90,000 acres in 41 towns.

New Jersey. Since the 1950's, New Jersey has lost at least 20 percent of its wetland resources to urbanization and intensive cropping. The legislature is formulating a bill to recognize, regulate, and preserve inland freshwater wetland.

Massachusetts. The state has a strong Wetlands Protection Act. The top money-making agricultural industry, cranberries, involves intensive wetlands management.

CHAPTER 12

Resource Projections: What Might the Future Hold?

This section discusses a detailed, in-depth analysis conducted over a period of years by researchers from several universities and by USDA analysts with expertise in the conservation and use of natural resources. Long term trends of agricultural commodity demand, resources available, and changes in technology were analyzed with computer models. A number of alternative scenarios were analyzed; three are discussed in this section.

The analysis suggests that, assuming intermediate rates of increase in export demand and in agricultural productivity, soil and water resources would be more than adequate to meet projected needs for food and fiber over the next 50 years. However, meeting the highest levels of demand considered at the lowest rate of productivity increase projected would require use of all available cropland by 2030.

The preceding chapters in this report described today's status and conditions of the Nation's soil, water, and related resources and evaluated the capability and limitations of those resources for meeting current demands. The Soil and Water Resources Conservation Act of 1977 also directs USDA to analyze resource capability and limitations for meeting future demands. In response to this directive, USDA first analyzed the major forces that affect demands on our soil and water and made separate projections of the highest, lowest, and an intermediate rate of change that could reasonably be expected in each of these forces. These major forces include 1) commodity demands, 2) demands for land and water for non-agricultural uses, 3) production technology, 4) productivity losses resulting from soil erosion, and 5) the policy and institutional environment. These projections and their interactions were analyzed using a mathematical model of the Nation's agricultural sector developed by the Center for Agricultural and Rural Development (CARD) at Iowa State University. 1/ This chapter describes these separate and combined projections of resource conditions.

1/ English, Burton C., Klaus F. Alt, and Earl O. Heady. 1984. A documentation of the Resource Conservation Act's assessment model of regional agricultural production, land and water use, and soil loss. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa.

Combined projections were made for three scenarios. The "intermediate" scenario represents a continuation of current trends in resource use. In the "high stress" scenario, fewer resources were assumed to be available than for intermediate conditions, increases in productivity resulting from new technology were assumed to be lower, and exports were assumed to be higher. In the "low stress" scenario, the opposite conditions were assumed.

The analysis projects production of the entire farming sector. For the major crops and livestock, the CARD linear programming model calculated production and regional distribution. For crops and livestock not included in the CARD model, projections were made separately and then incorporated into the CARD results.

The acreage required for all crops is projected in the analysis. The CARD model projects the production of major crops--corn for grain, corn for silage, soybeans, wheat, barley, cotton, legume hay, nonlegume hay, oats, peanuts, sorghum for grain, sorghum for silage, sunflowers, and summer fallow. The model calculates the pattern of production that would provide the required quantities of these crops for the least total cost and without exceeding the level of resources available. Crops that were not projected in the CARD model include vegetable crops, tree and fruit crops, rice, tobacco, and other minor crops. The acreage required for these latter crops is projected by the USDA Economic Research Service's National Interregional Agricultural Projection system (NIRAP) and subtracted from the acreage available to the CARD model.

The CARD model includes a pasture/range sector and a livestock sector as new components of the system. The model projects the livestock needed to meet estimated demands for beef, pork, and dairy products. It projects the least-cost mix of feed that would meet the nutrient requirements of these animals. It also projects production of the feed and forage needed for other types of livestock. The numbers and distribution of these animals and the amounts and types of feed needed for them are projected by the NIRAP model based on current trends and added to the quantities the CARD model was required to project.

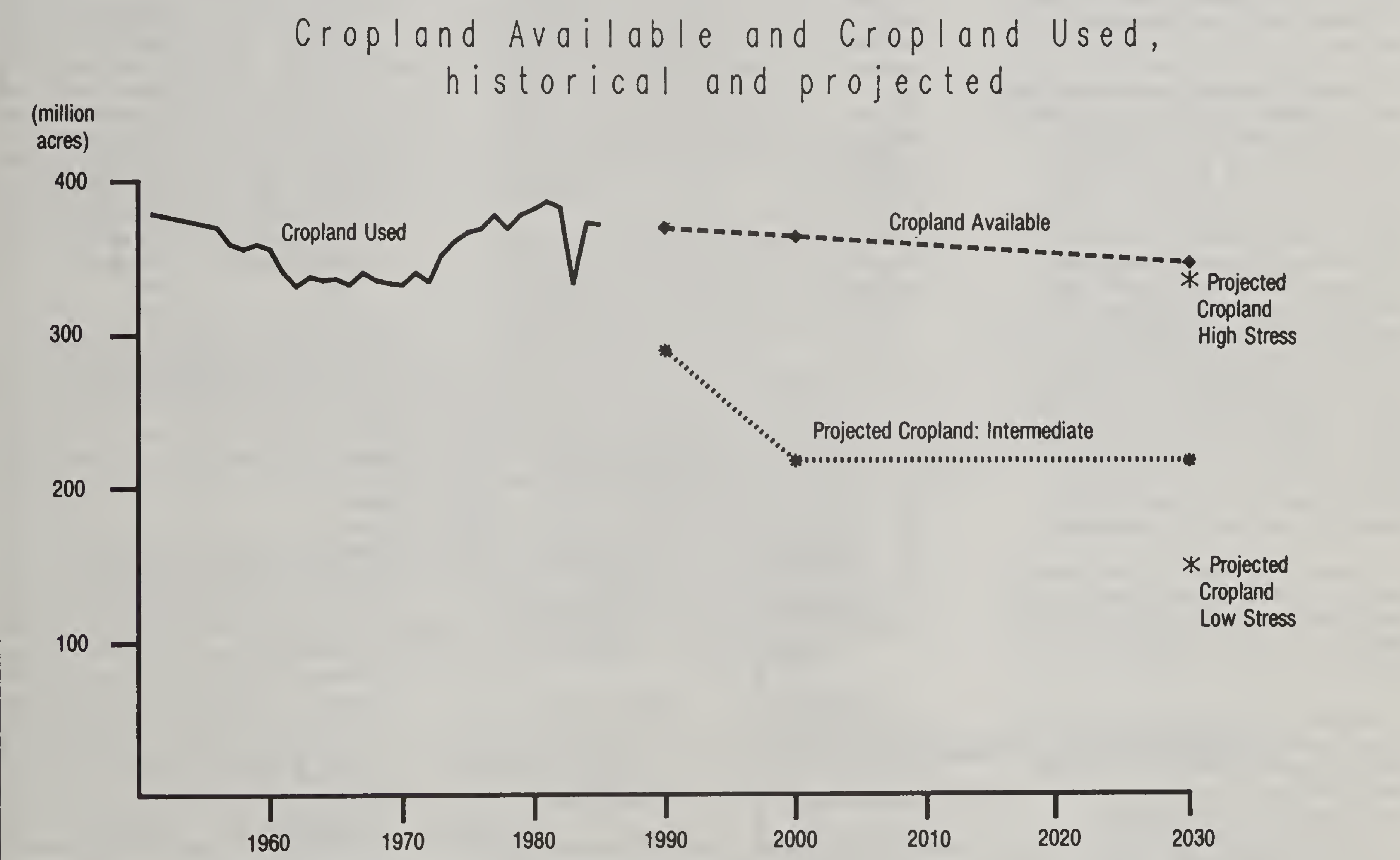
The analyses discussed in this section are not **predictions** of future conditions. They are extrapolations of current trends based on a set of assumptions about technology growth, export demand, and agricultural management, assuming constant prices and stability in other aspects of the production environment.

Weather and climate, an extremely important set of conditions, were not explicitly projected over the next 50 years. Implicitly, the trends of the past 30 years were extrapolated through the yield projections. Should predictions of a "greenhouse effect" and depletion of atmospheric ozone prove accurate, the effects on agricultural production would produce conditions much different from those projected in this analysis.

Cropland Projections: Will There Be Enough?

Under all of the scenarios projected for this appraisal, assumed demands for food and fiber in the year 2030 could be met on the cropland projected to be available (fig. 73). Under the "intermediate" scenario, which generally is continued current trends, production to meet demand in 2030 is projected to require slightly more than 218 million of the 347 million acres of cropland available. Under the "high stress" scenario, which combines higher export demand and smaller increases in yield, all of the 347 million acres available would be needed to meet demand.

For every crop except grain sorghum, the CARD model projects



In 1982, a total of 421 million acres of cropland were available, according to the 1982 National Resources Inventory. Cropland available in the future was assumed to decrease as a result of conversion to other uses and removal of highly erodible land from cultivation.

Production modeled for 1982 did not equal actual production in that year. Production figures from the Census of Agriculture were reduced by the amounts that went into stocks. The model projected these quantities actually consumed in 1982 could have been produced on 309 million acres of cropland. About 383 million acres were actually harvested in 1982.

The model was constrained to permit the acreage of cropland to change only slightly before 1990. Unless constrained, the model would project immediate shifts in production. In reality, such shifts take time to occur because of existing investments in production resources and costs of adjustments. The model projects dramatic declines in cropland after 1990 as the constraints are relaxed. By 2000, all constraints have been removed. In the real world, shifts of the magnitude projected in the analysis would likely require more time. Under "intermediate conditions," about the same number of acres would be required in 2030 as in 2000 because expected yield increases balance assumed increases in export demand.

Source: CARD/RCA model

Figure 73.--Projected acreage of cropland available and cropland used in the year 2030, alternative scenarios. For additional data, see appendix tables 48 and 49.

that, under intermediate conditions, fewer acres would be needed in 2030 than were harvested in 1982 (table 49). Even under high stress conditions, acreages of some crops are projected to be less in 2030 than in 1982.

The projected decline in total acres of cropland results from the interaction of several factors:

o Under intermediate conditions, export demand for major commodities is assumed to increase at rates that keep pace with the increases in yield that result from new developments in technology. (The assumed rates of increase in export demand and in yields were developed separately by separate groups of experts.) As a result, the acreage needed to supply export demand is projected to change only slightly (fig. 74). Only under assumptions of very high export demands and low rates of yield increase is the total acreage needed to meet export demand projected to increase.

o Domestic demand is expected to increase more slowly than yields. Therefore, the acreage needed to meet these needs is projected to decline.

o Large increases in the efficiency of livestock feed use are projected; that is, demand for livestock feed increases less than demand for livestock.

o Demand and yields are not the only factors that determine acreage requirements. The acreage requirements are based on the model's calculations of the least-cost pattern of crop production and livestock feed mix; projections of both the regional distribution of crops and the source of livestock roughage are greatly different from the existing situation.

Regional Results

Reductions in acreage are not projected to occur evenly across the country (fig. 75). Under all scenarios, the greatest reductions are projected for the Plains and Mountain States. Both dryland and irrigated acreages there are projected to decrease.

Table 49.--Projected cropland use in 1982 and 2030

Crop	1982 Actual	1982 Projected 1/	2030 Intermediate	2030 High stress
	(million acres)			
Barley	9.1	6.8	6.	5.3
Corn	72.7	62.1	50.2	92.3
Cotton	9.7	9.8	3.4	10.2
Hay	59.8	39.2	8.3	6.1
Oats	10.3	5.1	.9	5.
Peanuts	1.3	1.1	.6	2.4
Silage	8.9	1.1	1.3	1.
Sorghum	14.1	13.8	16.6 2/	10.2 3/
Soybeans	69.4	66.3	62.7 4/	100.7 5/
Summer fallow	31.	17.8	2.6	7.7
Sunflowers	4.7	2.1	1.6	1.8
Wheat	77.9	57.5	50.5 6/	86.8 7/
Other 8/		28.3	24.1	24.1
Total	383.	309.	218.	346.

1/ The model was required to simulate production of 1982 harvest minus the quantities that went into stocks.
2/ Includes 2.2 million acres double-cropped.
3/ Includes 1.1 million acres double-cropped.
4/ Includes 7.8 million acres double-cropped.
5/ Includes 16.8 million acres double-cropped.
6/ Includes 10.1 million acres double-cropped.
7/ Includes 18.4 million acres double-cropped.
8/ Includes crops not projected separately in the CARD model but projected by the NIRAP system.
Source: 1982 Actual: Agricultural Statistics.
Projected: 1982 and 2030--CARD/RCA model.

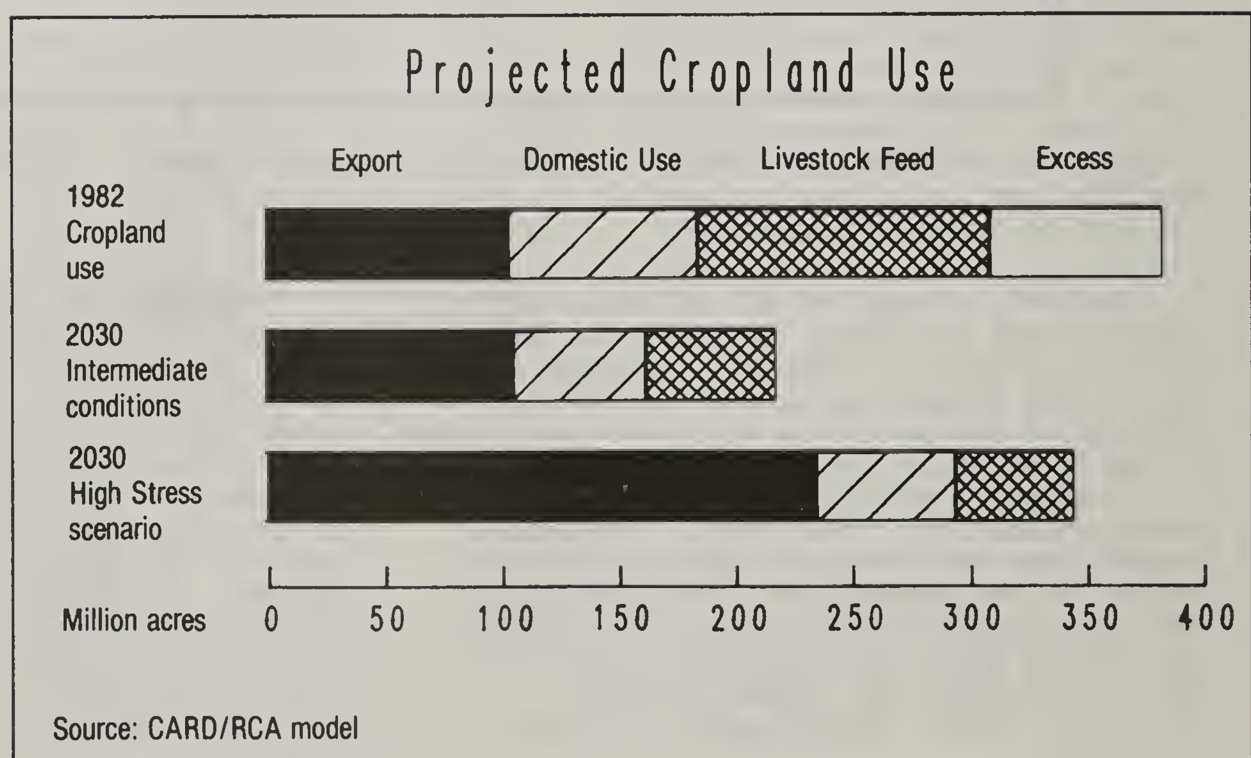


Figure 74.--Projected cropland acreage needed to meet domestic, livestock, and export demand.
"Excess" is the difference between the acreage that the model projected would be needed to produce the quantities consumed in 1982 and the acreage that was actually harvested that year.

The projections of cropland acreages are not predictions of future occurrences.--They show cropland estimated to be needed assuming specific demand and productivity trends with other parameters fixed. They do not account for the possible uses of cropland available but not harvested. They do not incorporate "frictional" categories such as land in failed crops and in cropland not farmed. The acreage in these categories has been estimated to range between 14 and 35 million acres. 2/ Therefore, the acreages projected for 2030 represent a "floor" of land use, under-representing future cropland acres by a minimum of 14 million acres and probably by more.

Farming may change in ways that modify the projected land use.--The Nation's excess capacity in agriculture--estimated at 44 million acres in 1986--is projected to increase under the intermediate and low-stress scenarios.

These results are startling viewed in the context of history and recent experience and compared to other long-range agricultural projections (for comparisons with other recent studies see page 153). Essentially, the projections of the intermediate scenario say that because of advances in agricultural technology, increasing supply will outstrip increasing demand, resulting in continued downward pressure on agricultural commodity prices and land values. Higher per-unit-cost farms will not be able to produce competitively. The projected gap between cropland available and cropland needed, even after accounting for the Conservation Reserve, means that some combination of several possible outcomes is likely to occur: 1) land will be idled (even abandoned); 2) government programs will serve to keep demand abreast of supply, allowing higher per-unit-cost farming to continue; 3) alternative land uses will become attractive because of the decline in land prices (these uses could be alternative crops such as trees or exotics, or nonagricultural uses); or, 4) familiar crops will continue to be produced but with a production system using more land relative to labor and capital inputs to take advantage of lower land prices. Some of these outcomes could lower production or increase cropland needed, compared with the projections under the intermediate and low stress scenarios.

The RCA analysis implicitly assumes that the incentives for the application of inputs over the next 50 years will remain approximately as they are in the present. This assumption is undoubtedly false. Incentives that exist in an era of prices higher-than-market and "set aside" acres on virtually every farm would change in the decision-making environment implied by the projections methodology: market-clearing prices and no government-subsidized surpluses. This difference in input-use incentives coupled with lower land prices would serve to alter production toward "land-using" technologies and away from "land-saving" technologies. 3/

2/ Dvoskin, Dan. 1986. Excess capacity and resource allocation in agriculture, 1940-1985. Agricultural Outlook. USDA, Economic Research Service, Econ. Ref. Serv. AO-124:31-33.

3/ Crosson, Pierre R., and Sterling Brubaker. 1982. Resource and environmental effects of U.S. agriculture. Resources for the Future, Washington, DC.

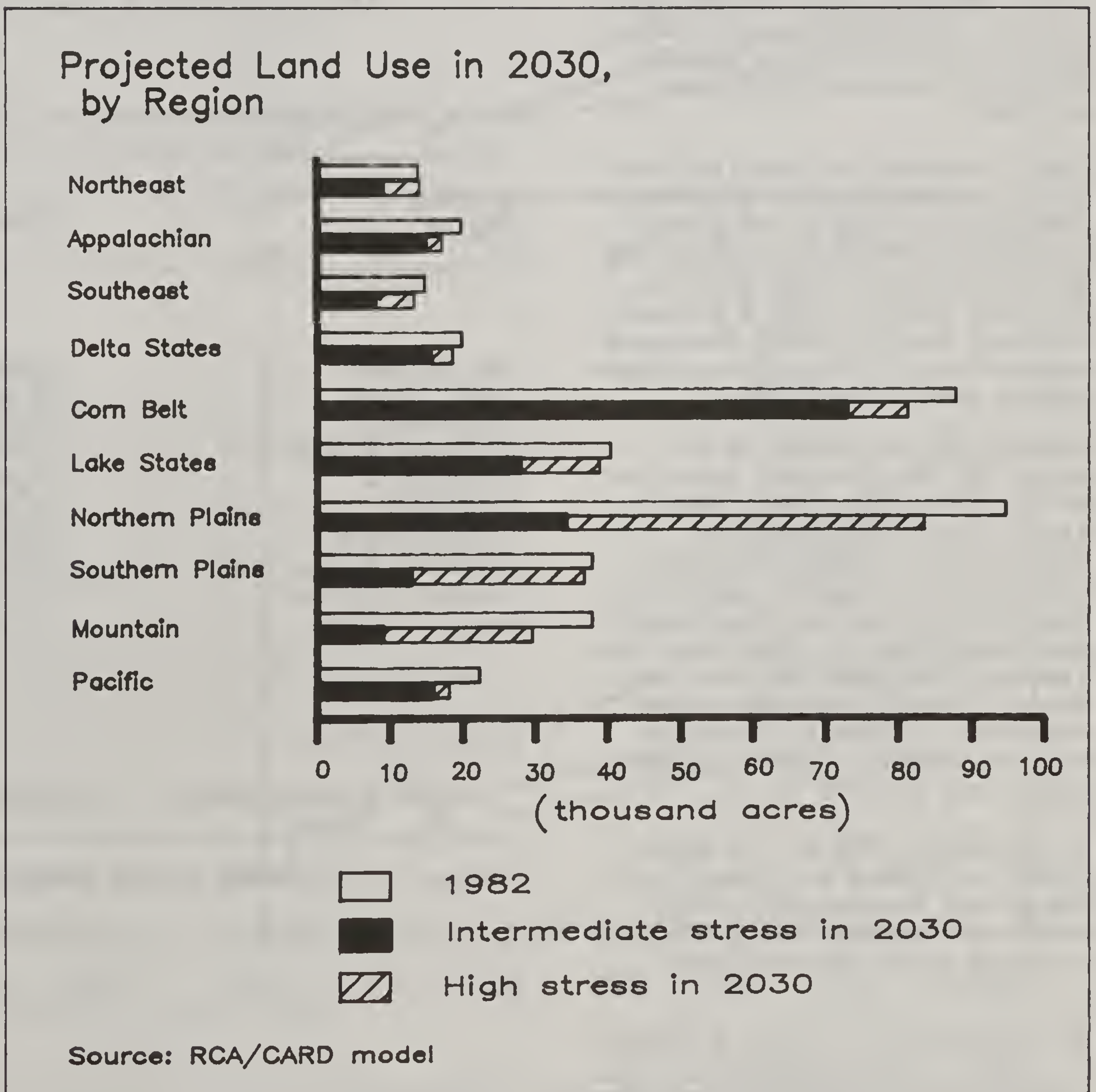


Figure 75.--Projected acreage of cropland in each farming region, 2030.

Forces Affecting Cropland Requirements

Demand

Domestic demands depend largely on population and income and are relatively easy to project, given acceptable population and income projections. Based on population and income estimates (appendix table 50) from the Bureaus of Census and Economic Analysis of the Department of Commerce, domestic demand for major commodities is projected to rise (table 50).

The Census Bureau's projections of population by state show significant differences in population trends among states and among regions (table 51); regional shifts in population could significantly affect resources in some areas. Projections are that fewer people will live in the Northeast, the Lake States, the Corn Belt, and the Northern Plains in 2030 than in 1990.

Export demands, as the last few years have shown, are volatile, depending as they do on global economic conditions, weather and climate patterns, and politics. For this report, USDA's Economic Research Service (ERS) developed projections of alternative future export levels (fig. 76).

Because export demand is so volatile, the greatest chance of error in the long range projections lies in estimates of agricultural commodity exports. U.S. exports expanded rapidly in the 1970's--tripling in tonnage and sextupling in value--and then rapidly declined. The rise was fueled by world economic growth, expansion of credit, new trade with previously closed economies, and a weak dollar. 4/

In the early 1980's, the export market collapsed as a result of the global recession in 1981, which strengthened the dollar, fostered trade barriers, and

4/ Drabenstott, Mark. November 1985. U.S. agriculture: the international dimension. Economic Review, Federal Reserve Bank of Kansas City.

Table 50.--Projected demand for wheat, corn, and soybeans, selected years 1982-2030

		Intermediate			High stress
	1982	1990	2000	2030	2030
	(billion tons)				
Corn:					
Domestic	0.7	1.5	2.0	2.1	2.1
Export	1.9	2.4	3.2	5.3	11.3
Livestock	4.1	3.3	2.5	2.5	3.6
Soybeans:					
Domestic	0.2	0.3	0.3	0.4	0.4
Export	0.9	0.9	1.3	2.4	4.8
Livestock	1.1	1.0	1.2	1.4	1.3
Wheat:					
Domestic	0.7	0.8	0.8	0.9	0.9
Export	1.5	1.5	1.8	2.8	5.5
Livestock	0.1	0.3	0.0	0.0	0.0

Source: 1982--USDA, 1985. Agricultural Statistics.
1990-2030--USDA Economic Research Service.

Table 51.--Projected population, 1990, 2000, 2030, by region

Farming region	Projected population		
	1990	2000	2030
	(thousands)		
New England	55,144	53,584	41,761
Lake States	18,563	18,652	16,847
Corn Belt	35,818	34,949	27,783
Northern Plains	5,420	5,450	4,936
Appalachia	23,493	25,071	27,975
Southeast	27,435	32,489	47,258
Delta States	10,089	10,943	12,817
Southern Plains	21,027	24,651	35,085
Mountain States	15,748	20,226	34,289
Pacific States	35,328	40,088	52,911
Contiguous U.S.	248,065	266,102	301,660
Alaska & Hawaii	1,635	1,898	2,640
United States, total	249,700	268,000	304,300

Source: U.S. Bureau of the Census.

forced restructuring of debt in many developing nations, requiring austerity, discouraging imports, and encouraging exports. At the same time, international competition increased because of increased productivity worldwide. This increase in productivity resulted partly from the advances of the Green Revolution and partly from agricultural policies offering price incentives and subsidies to farmers. Twenty-five countries, including former net importers such as Finland, Saudi

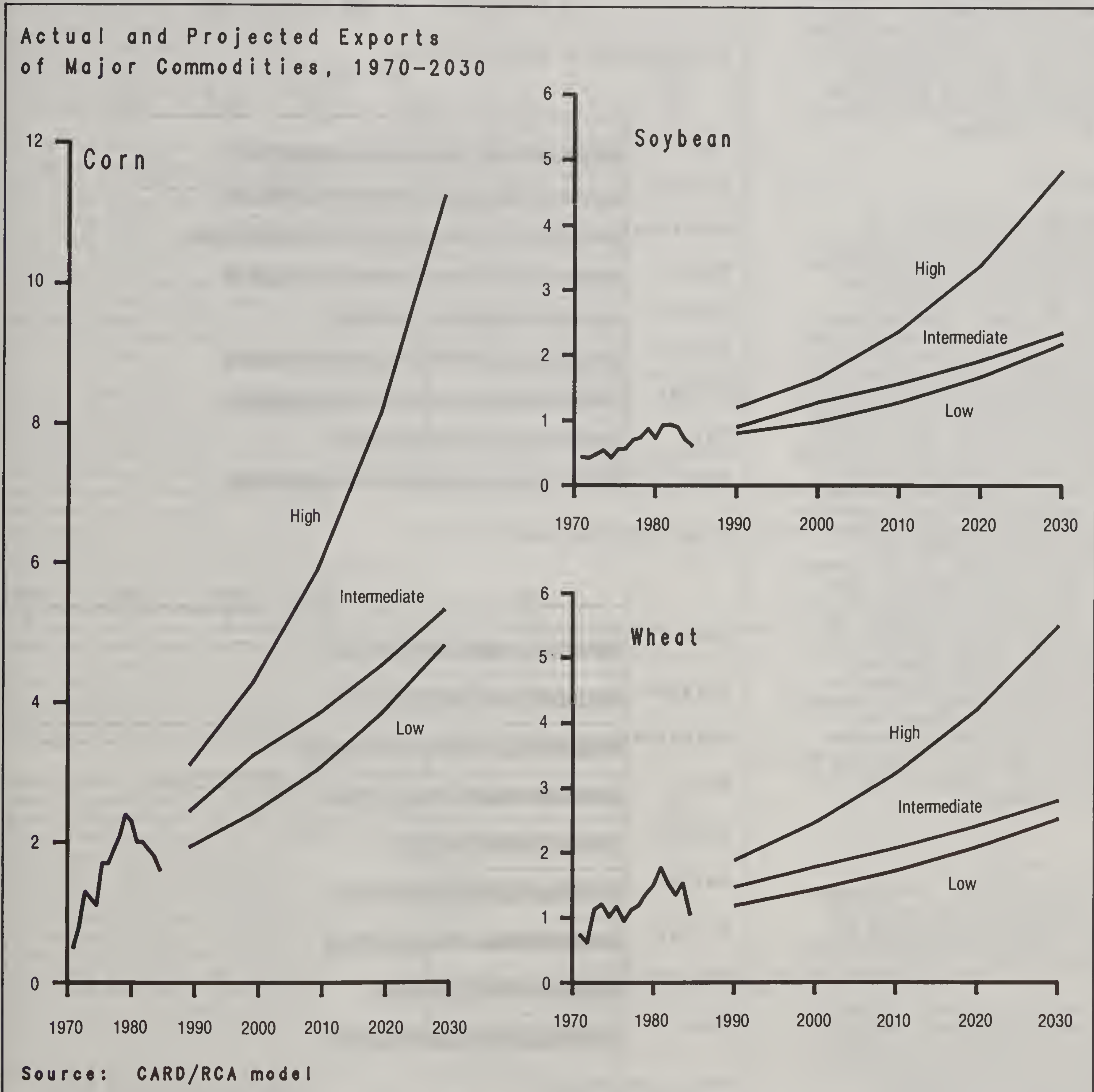


Figure 76.--Corn, wheat, and soybean exports, historical and projected. See appendix table 51.

Arabia, and the People's Republic of China, had farm surpluses in 1985. 5/

Although export levels in the mid 1980's are lower than seemed likely a decade ago, it is unlikely that exports will stagnate or decline permanently. World population and income will continue to grow, and American farms will become more competitive because of improved production efficiency and advanced processing and marketing.

Technology

According to the Office of Technology Assessment, advances in biotechnology and information technology will revolutionize plant and animal production within 15 years. The estimates of productivity improvement used in this appraisal were developed in a symposium held in 1982. 6/ Symposium participants estimated future productivity increases on the basis of their work in agricultural research. The estimates of the "most probable" rates of increase in yield (used in the intermediate scenario) range from a low of 0.7 percent per year between 2001 and 2030 (for alfalfa) to a high of 2.6 percent per year between 1982 and 2000 (for soybeans). Under these intermediate projections, yields of feedgrains, wheat, and soybeans would double, and livestock productivity would increase 60 to 70 percent (fig. 77). Higher rates of yield increase were projected for the "low stress" scenario, and lower rates for the "high stress" scenario (appendix tables 52 and 53).

5/ Avery, Dennis. 1986 (unpublished). Update on rising world farm output. Speech at Valley National Bank Agricultural Symposium, Phoenix, Arizona.

6/ English, Burton C., James A. Maetzold, Brian R. Holding, and Earl O. Heady, eds. 1984. Future agricultural technology and resource conservation. Proceedings of the RCA Symposium held December 1982. Iowa State University Press, Ames, Iowa.

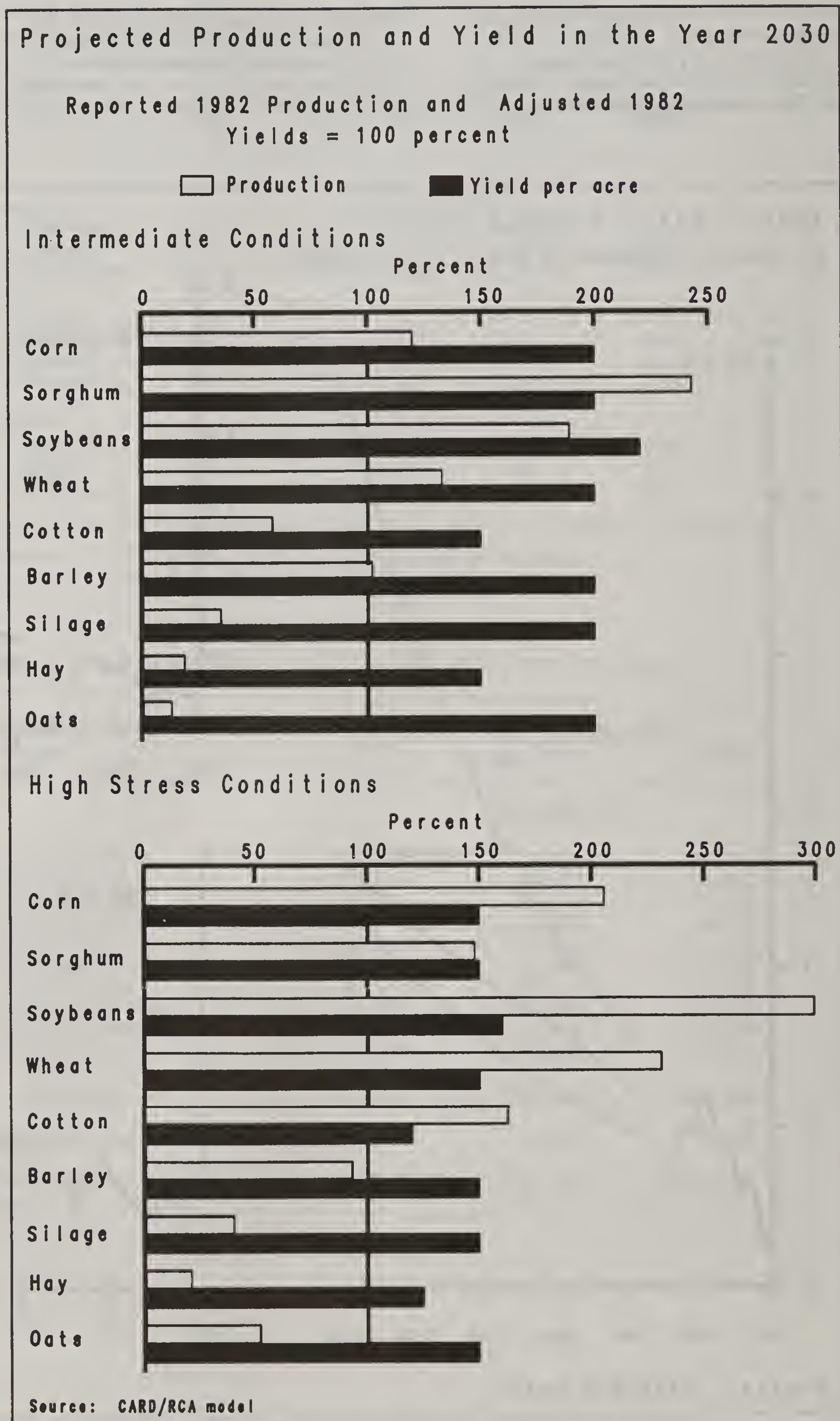


Figure 77.--Projected demand and yield in 2030 as a percentage of 1982 values, intermediate and high stress conditions. Projected yields are assumptions developed at the 1982 RCA symposium.

Irrigation Projections: Less Is Projected

The acreage of irrigated cropland is projected to decline under intermediate and low stress conditions and to increase under high stress conditions. The projections for 2030 range from about 20 million acres to 68 million acres (fig. 78). In 1982, irrigation systems were in place on about 60 million acres of cropland and 5 million acres of pastureland. Irrigation water was applied on about 49 million acres.

Under intermediate conditions, slightly more than 30 million acres of cropland are projected to be irrigated in 2030. This is a much smaller irrigated area than has been projected by studies based on historical trends in irrigation development. The NIRAP model, for example, projects that slightly more than 80 million acres would be irrigated in 2030. 7/

Projections of the crops that will be irrigated differs considerably from the early 1980's. In 1982, much of the cropland irrigated was planted to the major crops -- feedgrains, wheat, soybeans, hay, cotton -- that are projected in the CARD analysis (table 52). Less than half was planted to rice or to high-value crops such as orchard crops and vegetables. In 2030, such specialized crops are projected to make up a much greater part of irrigated acreage under intermediate and low-stress conditions. Under high-stress conditions, the greatest increase in irrigated acreage is projected for wheat.

Because the acreage of irrigated land is projected to decrease under intermediate and low stress conditions, the need for irrigation water is projected to decrease. Under intermediate conditions, the net depletion for all irrigated crops is projected to decrease from 79 million acre-feet in 1990 to 47 million acre-feet in 2030. Only 24 million acre-feet would be used for major crops. In the low stress

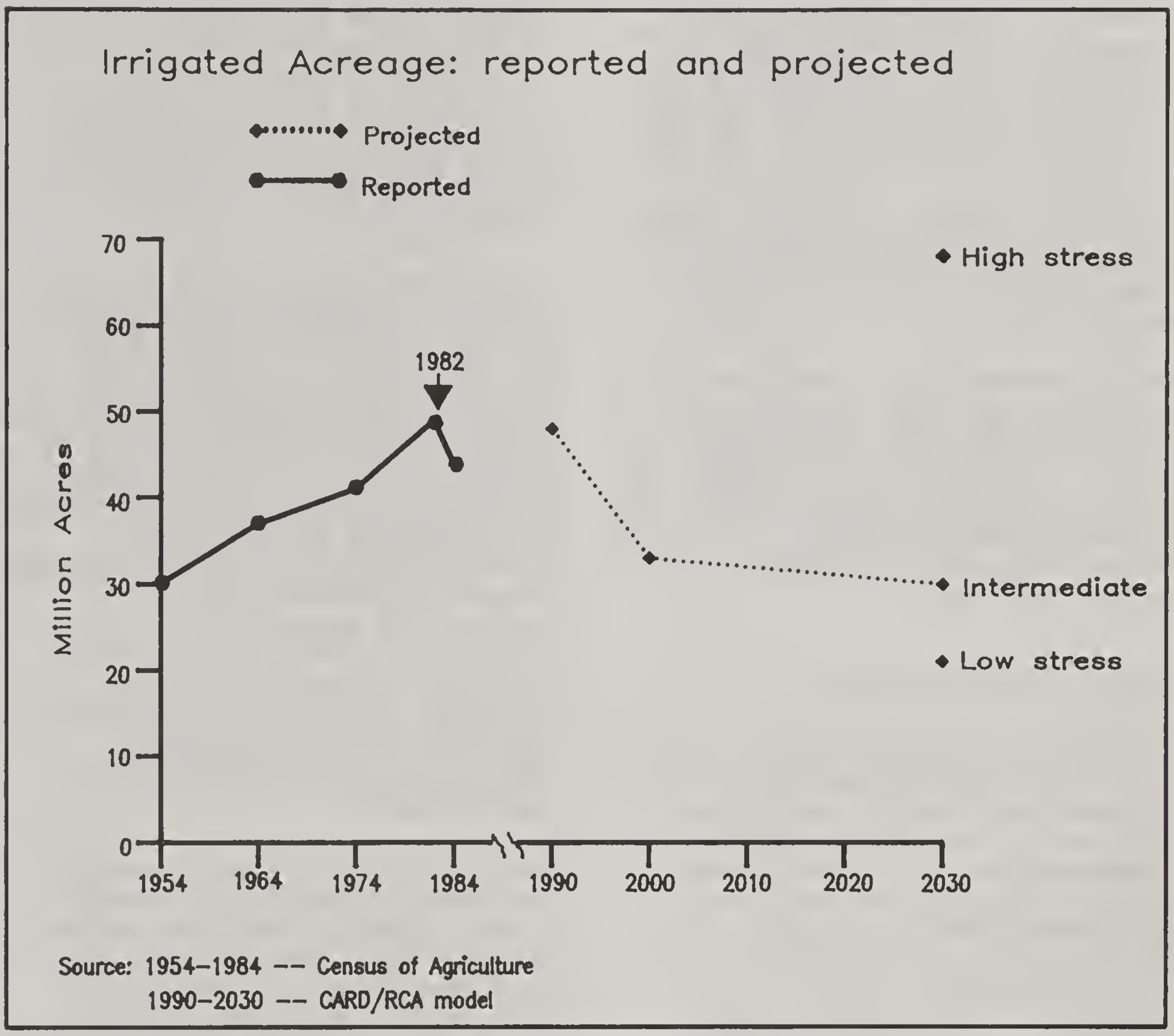


Figure 78.--Irrigated cropland, historical and projected, 1982-2030.

Table 52.--Irrigated acreage, selected crops, 1982 and 2030.

	1982	2030 Intermediate	2030 High Stress
	(million acres)		
Irrigated land 1/	49	30 2/	68 3/
Hay	8.5	.4	3.
Corn	8.5	4.7	19.2
Wheat	4.7	7.2	23.9
Cotton	3.4	2.5	2.5
Soybeans	2.3	.9	4.8
Sorghum	2.3	2.8	2.6

1/ The 1982 acreage includes irrigated pasture as well as cropland. The projections are for cropland only.
2/ Includes 2.3 million acres double-cropped, mostly in wheat and sorghum.
3/ Includes 1.6 million acres double-cropped, mostly in wheat and sorghum.

7/ The assumptions on which the NIRAP projection is based, however, differ from those of the intermediate scenario.

scenario, a combination of high yields, increased water use efficiency, and lower demands are projected to reduce water use to 30 million acre-feet per year for all crops and to 8 million for the major crops. The high stress scenario, however, requires 100 million acre-feet of water, three-fourths of it for major crops.

Under intermediate conditions, slightly less than 40 percent of net depletion used for major crops is projected to be from surface supplies. Under high-stress conditions, only 20 percent would be surface water (fig. 79).

Water Supply Assumptions

Estimates of water supplies used in this report are based on inventories taken in the Second National Water Assessment and augmented from U.S. Geological Survey data. 8/ Estimates were prepared of surface water, rechargeable ground water, and non-rechargeable ground water supplies. The surface water supply estimates for the intermediate scenario represented "dry" weather conditions; that is, in 8 years of every 10, streamflows could be expected to be greater than those assumed in the analysis. Basing projections on "average" flows, however, could have resulted in misleading projections because the model does not take into account problems and periodic disruptions that are inevitable in dry years if "average" flow is fully used.

Under intermediate conditions, irrigation efficiency was assumed to be equal to efficiencies in the early 1980's. In the high stress scenario, water use was assumed to be 90 percent as efficient as in the intermediate case. In the low stress scenario, water use efficiency was assumed to be 110 percent of that in the intermediate scenario, and surface water supplies were assumed to be greater because average levels of precipitation (those that occur in 8 of 10 years) were assumed to occur continuously.

In this analysis, the water supplies available for withdrawal and consumption for agriculture are limited to the quantities available after nonagricultural needs are met. Projected use of surface water for all purposes, however, is not allowed to exceed 70 percent of average flow. Thirty percent must remain in the stream to provide survival habitat for aquatic life. For basins where interjurisdictional treaties or compacts require outflows greater than 30 percent, the model is constrained to ensure that the treaty requirement is met.

There has been a trend toward increased irrigation in eastern states, less to increase yields than to reduce the risk of crop loss resulting from drought in some years. This analysis may underestimate irrigation in these areas because the model does not consider this risk.

For the crops considered in the CARD model, erosion is projected to decrease from an average of 6.9 tons per acre annually in 1990 to 3.7 tons per acre annually in 2030 under intermediate conditions, assuming full implementation of the conservation title of the Food Security Act of 1985 (fig. 80). Total erosion on cropland in major crops is projected to decrease from 1.8 billion tons to 0.78 billion tons during that period. Erosion on land in other crops is not projected.

The effects that the conservation title of the Food Security Act of 1985 are projected to have on erosion are considerable. Achieving the erosion control objectives modeled would result in much greater reduction than would be achieved without the Food Security Act. Even without the act, however, the economic conditions simulated would result in substantially less erosion than occurred under 1982 management. The projected decrease in wind erosion results from the projected decrease of cropland in regions where wind erosion is a

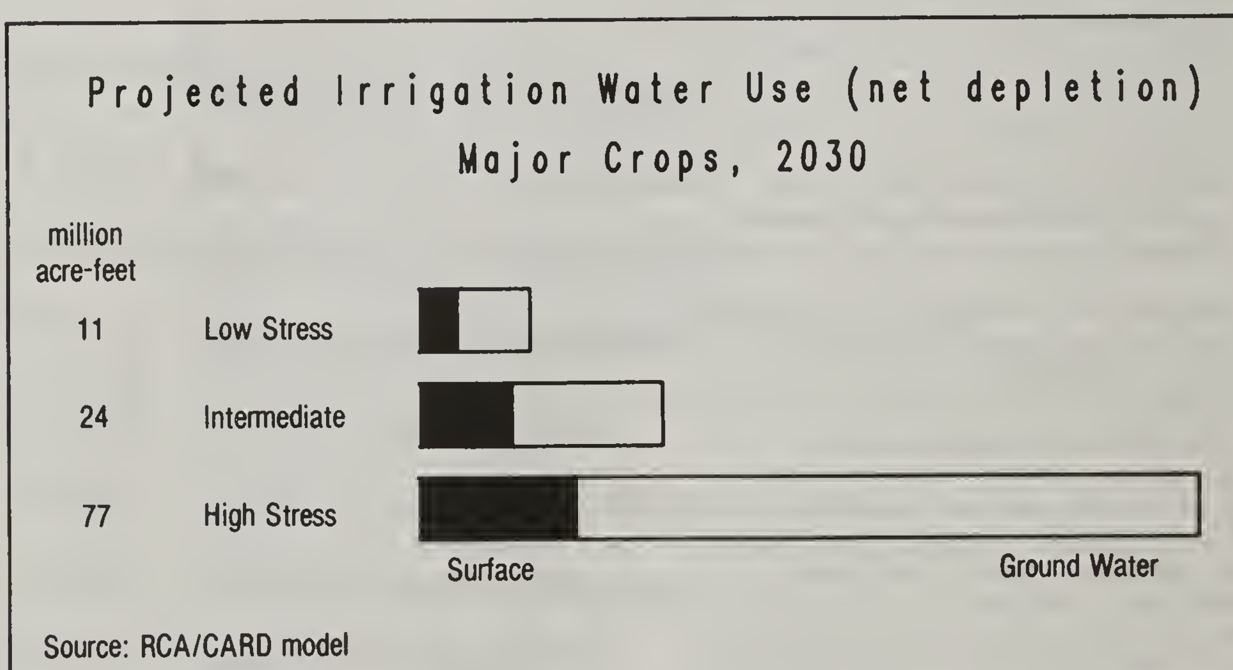


Figure 79.--Ground water and surface water used for irrigation, 2030.

8/ Smith, Elwin G., LeRoy T. Hansen, Burton C. English, and Sherry J. Wise. 1984. The CARD/RCA water sector model. Center for Agricultural and Rural Development, Iowa State University. CARD Series Paper 84-1.

hazard. This shift in production is projected primarily because production costs are lower in other areas. The decrease in sheet and rill erosion results mostly from the projected decrease in cropland acres and the increased use of conservation tillage as a consequence of assumed high energy costs.

The conservation title of the Food Security Act of 1985 authorizes extensive new conservation efforts. The Conservation Reserve authorized by the Act provides for establishment of vegetative cover for 10 years on about 10 percent (45 million acres) of the Nation's cropland. The Highly Erodible Lands provision (Conservation Compliance and Sodbuster), discourages farming of highly erodible lands without protection against erosion. Conservation Compliance regulations require that by 1995 operators who wish to participate in USDA programs must implement a conservation plan on all highly erodible cropland that was used for crop production between 1981 and 1985. Farmers who "sodbust" highly erodible land that was not used for crop production between 1981 and 1985 must have a conservation system in place before production of an agricultural commodity takes place if they wish to be eligible to participate in USDA programs.

For this appraisal, an analysis was made to project the effects of implementing these new policies. The model was run twice for intermediate conditions; one run incorporates constraints that approximate implementation of the act, the other omits them. (All previous references to "intermediate conditions" report projections for the intermediate conditions including the Food Security Act.)

When the Food Security Act constraints are not included in the model, projected erosion for intermediate conditions doubles (table 53). Under intermediate conditions, however, erosion is projected to decline from 1982 levels, even without the Food Security Act.

Both the Conservation Reserve and Conservation Compliance features of the Food Security Act were incorporated into the analysis. To simulate the Conservation Reserve, 40 million acres were removed from the cropland available to the model. A total of 15 million of the least productive acres eroding at 15 tons per acre or greater and 25 million of the least productive acres eroding at 10 to 15 tons per acre were removed from consideration in the model. These acres were prorated across the country. These acres were removed from the base available to the model in 1990 and all following years.

The Conservation Reserve is a 10-year program, but the analysis tests the effects of permanently removing this much highly erodible land from cropping.

Conservation compliance was simulated by establishing limits on the percentage of cropland that could be projected to erode at more than 5 tons per acre. In 1990, no more than 40 percent of the cropland in production could be projected to erode at more than 5 tons per acre; this approximates the percentage of cropland reported eroding at more than T in the 1982 NRI. The

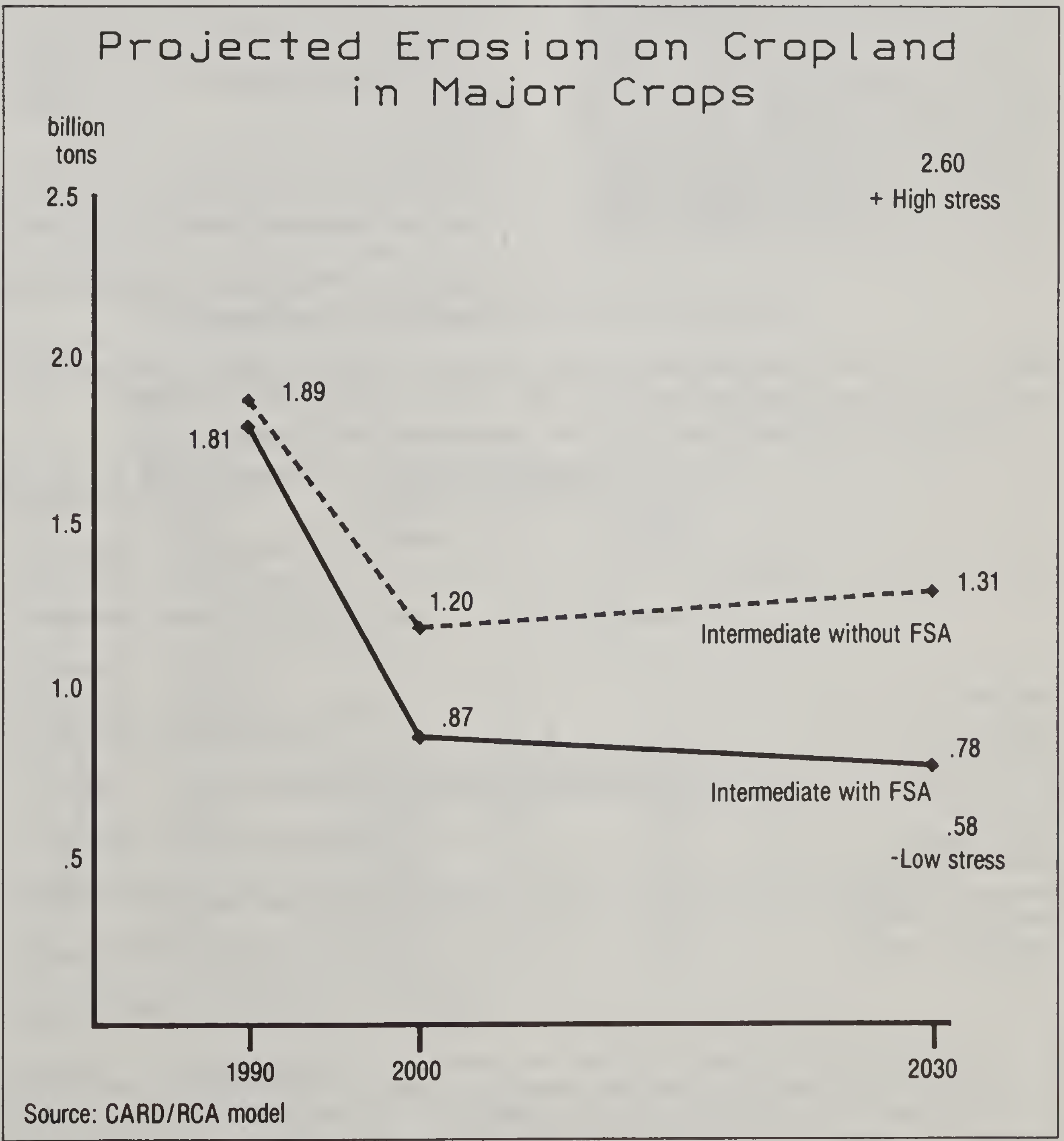


Figure 80.--Projected erosion, major crops.

percentage that could be projected to erode at more than 5 tons per acre was reduced to 25 percent in 2000 and to 15 percent in 2030.

The "Sodbuster" and "Swampbuster" provisions of the act are simulated also; no conversion from potential cropland into cropland was permitted.

In the analysis, use of two important conservation practices -- conservation tillage and terraces -- is governed largely by forces other than soil erosion reduction goals. Use of conservation tillage in the model results primarily from the assumed costs of energy, not the erosion constraints. Therefore, the percentage distribution of land among types of tillage is identical for the simulations with and without the erosion constraints (fig. 81). Even under high stress conditions and without the erosion restrictions imposed to simulate Conservation Compliance, the model projects 77 percent of cropland would be in conservation

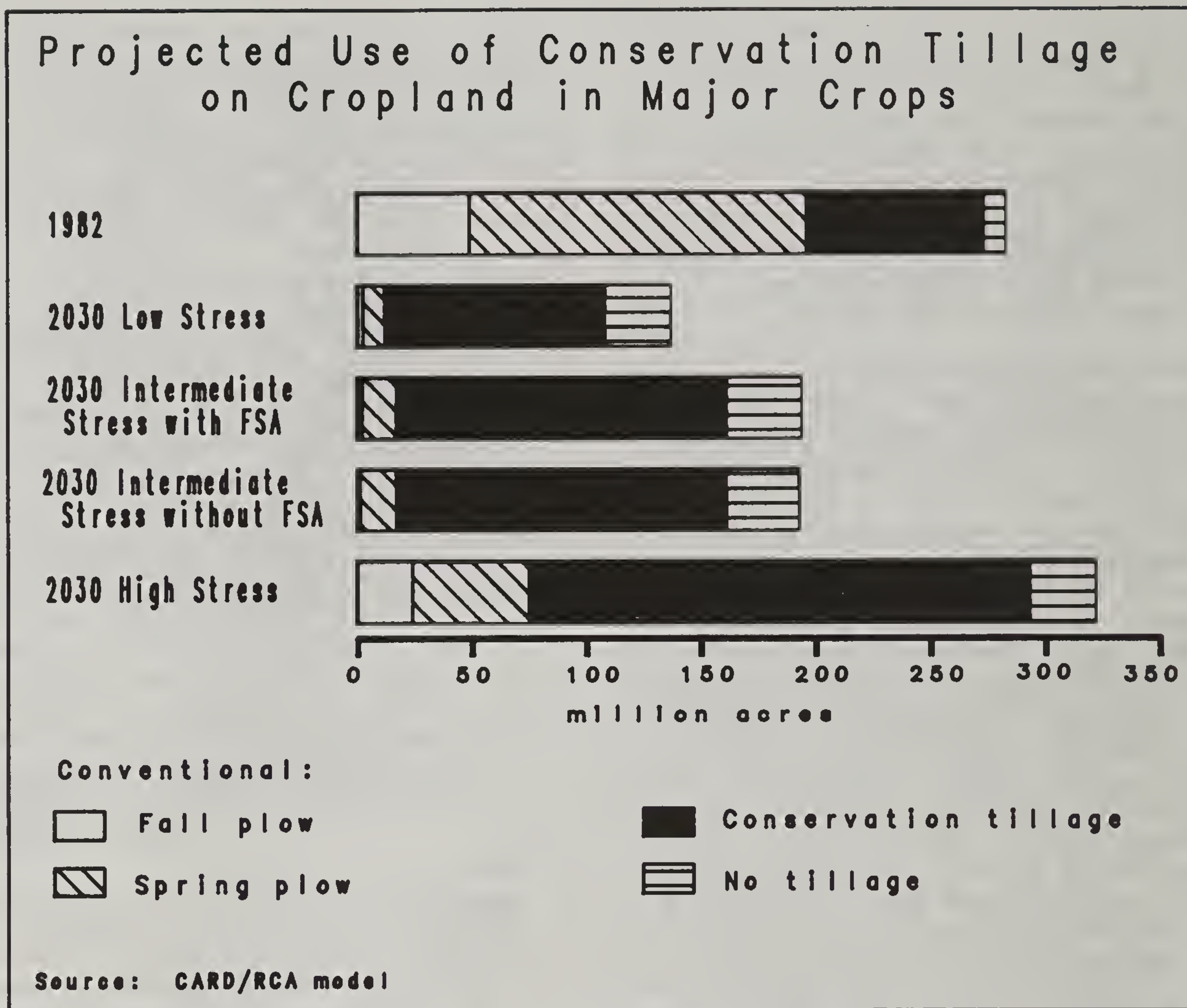


Figure 81.--Projected distribution of cropland among tillage systems, alternative scenarios.

Table 53.--Erosion on projected land in major crops in 2030, intermediate conditions with and without implementation of the Food Security Act of 1985

	Without FSA 1/			Assuming implementation of FSA 2/		
	Sheet and rill	Wind	Total erosion 3/	Sheet and rill	Wind	Total erosion 3/
	(tons per acre)		(million tons)	(tons per acre)		(million tons)
Northeast	4.3	0.4	33.0	3.2	0.3	28.2
Appalachia	3.5	0.7	37.5	1.7	0.6	39.8
Southeast	2.6	1.2	17.2	1.6	0.7	20.6
Delta States	4.5	0.8	67.8	2.7	0.7	41.3
Corn Belt	4.6	0.9	346.4	3.2	0.8	280.7
Lake States	2.5	1.0	78.6	2.0	1.0	72.5
Northern Plains	2.1	4.1	242.9	2.1	2.1	136.3
Southern Plains	2.7	12.6	228.3	1.5	6.5	90.3
Mountain States	1.8	11.1	179.1	0.8	3.7	31.3
Pacific States	4.2	2.6	80.2	1.0	1.8	35.4
Total			1,310.9			776.4

1/ No constraints on land used or on erosion.
2/ To simulate the Conservation Reserve, 40 million acres of land with high erosion rates and low productivity were removed from the base available to the model.
To simulate Conservation Compliance, the acreage projected to erode at more than 5 tons per acre was limited to 40 percent of the total in 1990, 25 percent in 2000, and 15 percent in 2030.
3/ Cropland in crops other than major crops is not considered.
Source: CARD/RCA model

tillage or no-till in 2030. Conservation Compliance was not included in the high stress scenario because, under conditions requiring all available cropland, commodity prices would be high and farm producers would not be as inclined to participate in commodity programs.

The number of acres protected with terraces is not selected by the model but is constrained to remain the same in all analyses; the model does determine the location of the terraces.

The conservation measures the model uses to meet the erosion goals are contouring and stripcropping. Contouring is projected on 15.5 million acres and stripcropping on 4.5 million acres when Conservation Compliance is assumed. When Conservation Compliance is not considered, contouring is projected on only 2.3 million acres and stripcropping on 2.6 million.

The model does not project that more land would be needed as a result of the erosion control activities; acreage projections for the two runs differ by only about one million acres. Nor does it project much change in regional distribution of cropland (fig. 82). Implementation of conservation compliance results in only slight projected reductions in acreage in the Southern Plains and the Mountain States beyond the reduction projected if the erosion constraints are not considered. Because the model does not include wind conservation measures other than conservation tillage, it must project production in areas where wind erosion is not a hazard or can be controlled by tillage alone.

The model projects that the least-cost strategy to meet the erosion-control requirements would involve greater use of irrigation and double-cropping than would be most cost-effective if erosion were not considered. A total of 30 million irrigated acres are projected, assuming implementation of the Food Security Act, compared to 20 million in the absence of the act. Most of the additional acres are irrigated with ground water. As part of the model's erosion control strategy, 2 million additional acres are irrigated (and double-cropped) in the Pacific region; 5 million additional acres in the Northern Plains and 1 million in the Mountain States are irrigated. In the Southern Plains, irrigated acres are projected to decrease by about 300,000 acres but, because of changes in the crops and location of irrigated acres within the region, about three times as much ground water is projected to be used to meet the erosion reduction restrictions.

A total of 10 million double-cropped acres are projected as part of the Food Security Act scenario, compared to about 100,000 acres projected without the act. Of these acres, 4 million are in the Appalachian region, 3 million in the Southeast, 2 million in the Pacific region, and about 500,000 in the Delta.

The Food Security Act conditions were included in the low stress scenario. The high stress scenario does not include Conservation Compliance but does include Swampbuster and Sodbuster. It also includes the 40-million acre Conservation Reserve and assumes that those acres would remain in uses other than cropland until after 2030. The analysis was structured to test whether resources are sufficient to meet needs without using the Conservation Reserve lands or the highly erodible land and wetlands protected under the Sodbuster and Swampbuster provisions. The analysis indicates that they are.

This high stress scenario, however, would occur in a period of very high commodity prices, which would provide market incentives for returning Conservation Reserve land to cultivation, draining wetlands, and plowing highly erodible land. It is likely that a large share of these lands would be under cultivation in a high stress future, exacerbating erosion, environmental degradation, and onsite and offsite social costs.

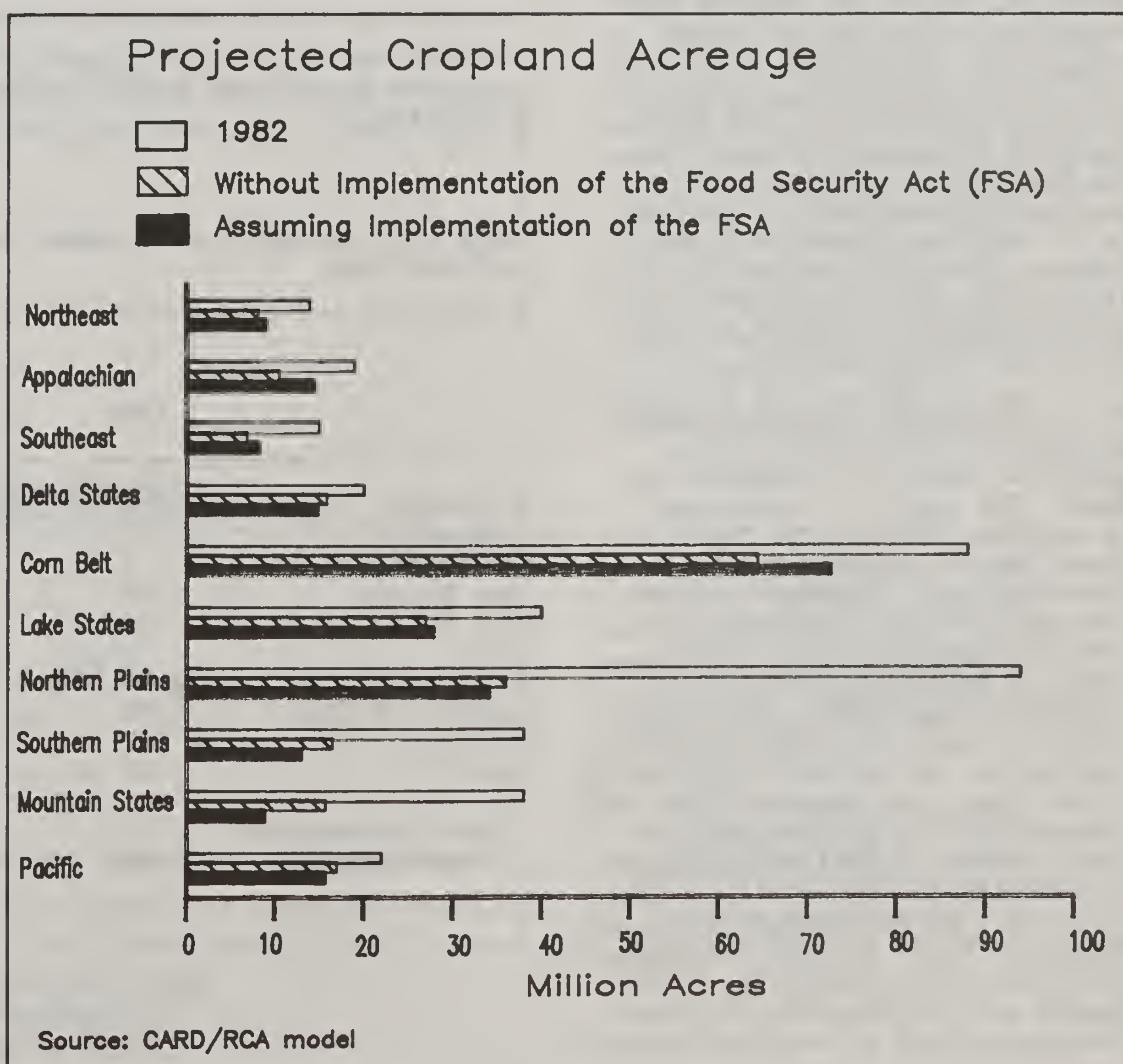


Figure 82.--Projected cropland acreage, by region, with and without implementation of the Food Security Act of 1985.

Livestock Projections: Increased Productivity

This analysis projects substantial changes in the feedgrain and forage rations fed to livestock and, under some scenarios, considerable shifting of livestock distribution among regions.

In general, projections are that the least-cost method of producing livestock would involve greater reliance on pastureland and rangeland and on silage and much reduced use of hay as a source of roughage, and that less corn and wheat would be fed. Use of other feed grains varies among scenarios (table 54).

The distribution of dairy production is not projected to change substantially at the regional level, because it is assumed that the current marketing system will continue to operate.

Projections are that under all scenarios, pork production would be less concentrated in the Corn Belt. In the 1982 calibration run, slightly more than 70 percent of all pork was produced there. In 2030, projections are that about half would be, ranging from 56 percent of production under high stress conditions to 49 percent for intermediate conditions with implementation of the Food Security Act conservation title. The regional share of pork production is projected to increase in the Northern Plains and Lake States. Under all except the high stress scenario, hogs would be fed much more sorghum and less corn in 2030 than in 1982.

Beef projections include separate projections for feeder cattle, grain-fed beef, and roughage-fed beef. The model is constrained to maintain the current ratio of grain-fed to roughage-fed beef throughout the simulation period. For some regions, the model projects changes in the regional share of production for various scenarios (table 55). Not only regional share of production but also actual production is projected to decline in a few areas (fig. 83). Compared to the 1982 projections, fewer pounds of beef are projected in 2030 in the Lake States under all four scenarios and in the Mountain States under all except the high stress scenario. Fewer pounds are projected in the Corn Belt under high stress conditions.

Projections for the Southern Plains are that production would increase under high stress conditions and under intermediate conditions with the Food Security Act. Without the act however, production in the Southern Plains is projected to remain at the 1982 level, and production in the Lake States and Corn Belt to increase above levels projected with the act. The model projects differing distribution of cow-calf and yearling operations for the intermediate and high stress conditions (fig. 84).

Table 54.--Projected livestock feed requirements (million units)

		2030		
		Intermediate		
	1982	with FSA	without FSA	High stress
Barley (bu)	74	106	139	66
Corn (bu)	2,543	1,051	1,217	1,648
Oats (bu)	139	0	0	211
Pasture/range (ton)	237	453	370	462
Sorghum (bu)	742	1,026	919	294
Soybeans (bu)	345	534	548	448
Wheat (bu)	136	0	4	0
Legume hay (ton)	101	18	41	28
Nonlegume hay (ton)	15	9	1	1
Silage (ton)	20	41	44	46

Includes rations for pork, beef, and dairy production, which are simulated in the CARD model, and for other livestock, based on NIRAP projections.

Table 55.--Projected percentage distribution of beef production, 1982 and 2030

		2030		
		Intermediate		
	1982	with FSA	without FSA	High stress
Northeast	2	3	4	3
Appalachia	2	8	9	6
Southeast	1	2	2	1
Lake States	17	6	5	1
Corn Belt	28	20	25	12
Delta	1	8	9	1
Northern Plains	10	12	12	15
Southern Plains	22	21	15	28
Mountain	12	7	8	16
Pacific	6	12	12	17
Total production (million cwt)	373	533	533	540

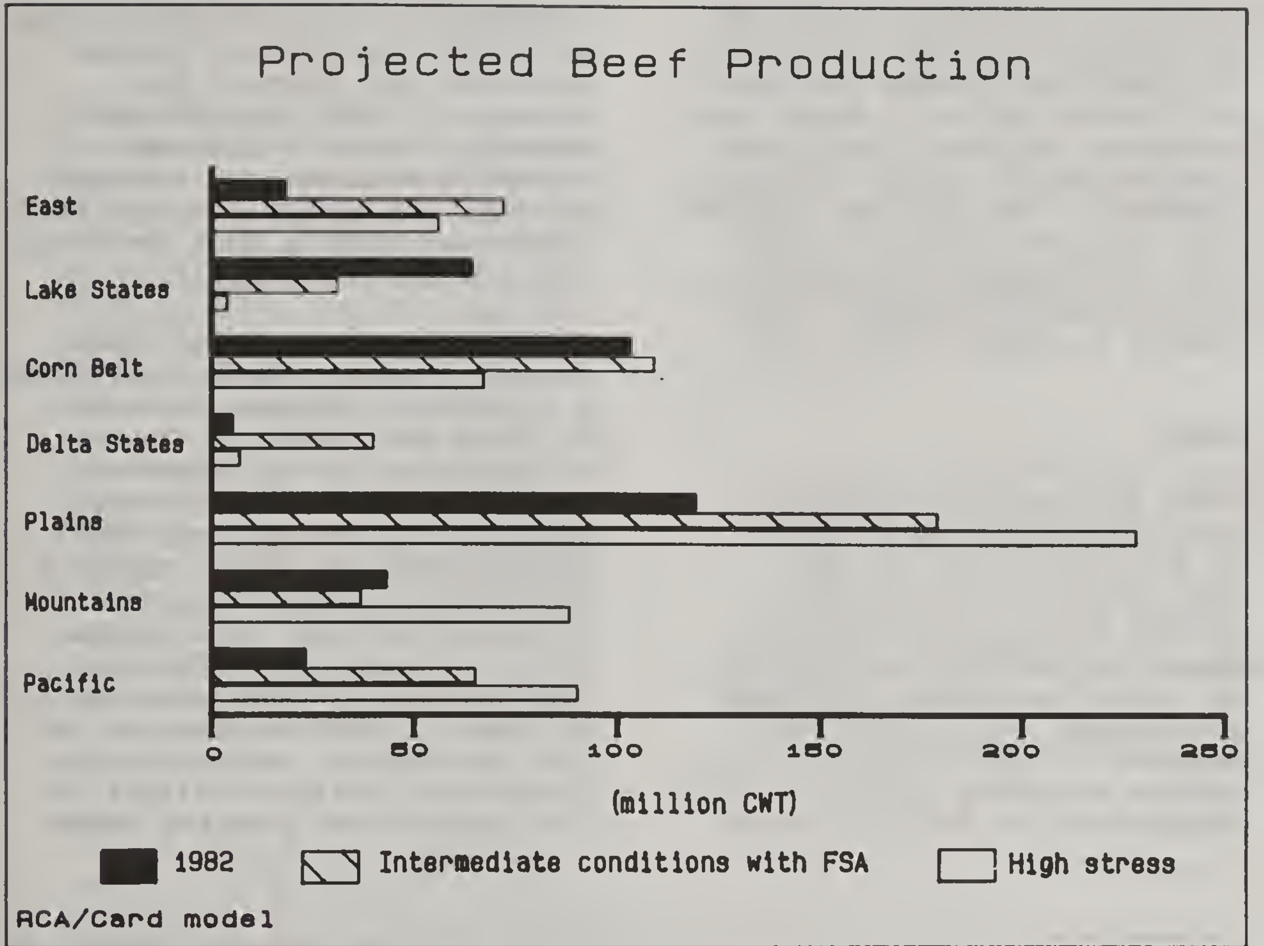


Figure 83.--Projected beef production, 2030. "East" includes the Northeast, Appalachia, and the Southeast regions. See appendix table 54.

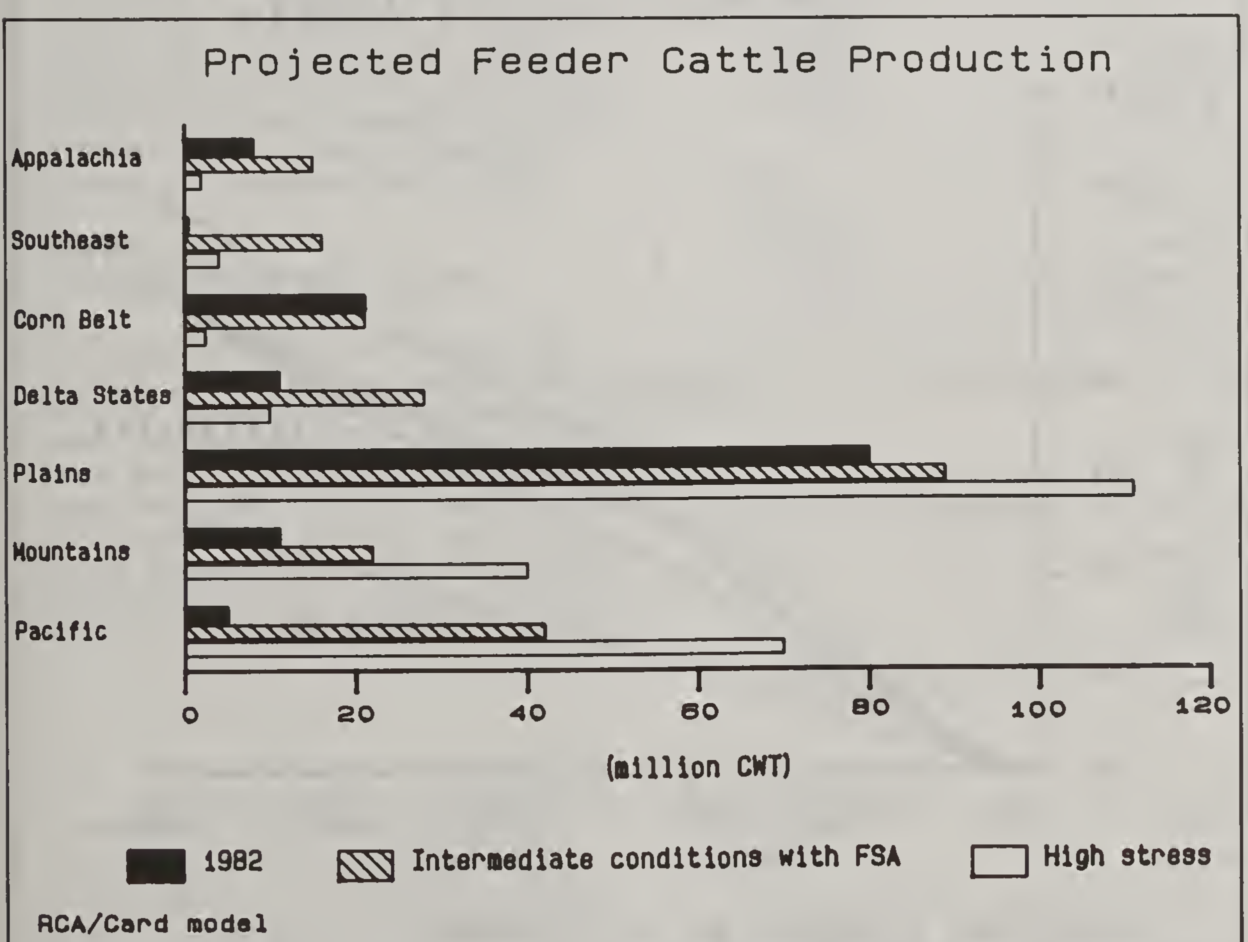


Figure 84.--Projected feeder cattle production, 2030. The Northeast and Lake States together account for less than 3 million cwt under all scenarios shown. See appendix table 55.

Other Possibilities: What Have Other Studies Projected?

This section compares the Second Appraisal projections with the results of other recent studies in which resource use and economic needs were projected for various periods of time. Comparisons are made with projections developed in the First RCA Appraisal, a USDA Economic Research Service study utilizing the National Interregional Agricultural Projection System model (NIRAP), 8/ and a study by Resources for the Future. 9/ Table 56 compares these studies' projections of cropland needed.

First RCA Appraisal

The results of the first appraisal conducted under the requirements of the Soil and Water Resources Conservation Act of 1977 differ markedly from those shown in the present study (appendix table 53). The Second Appraisal intermediate scenario projects slightly less than 220 million acres of cropland would be needed, the First Appraisal central case projected almost 390 million acres needed.

For the two appraisals, resource needs were projected to 2000 and 2030 using essentially the same techniques: major resource use factors were projected independently with their interactions estimated by the CARD model at Iowa State University. The modeling system used at Iowa State for the first appraisal differed in several respects from that used in the current analysis. The 1980 model did not incorporate an internal pasture/range/forest

8/ Quinby, William A. 1986. Review of RCA draft with CARD/NIRAP comparisons. Working papers. U.S. Department of Agriculture, Economic Research Service, Econ. Ref. Serv. Washington, DC.

9/ Crosson, Pierre R., and Sterling Brubaker. 1982. Resource and environmental effects of U.S. agriculture. Resources for the Future, Washington, DC.

sector nor an internal livestock production sector. The marketing/transportation system incorporated 28 market regions rather than the current 31. Changes in yield assumed to result from new technology were projected utilizing regional production functions developed at CARD. Productivity reductions resulting from erosion were projected by the Yield/Soil Loss Simulator developed by the Economic Research Service.

Projections of cropland use for the two appraisals differ because the demand and productivity projections used in the two analyses differ. The First Appraisal projected an average annual productivity increase of 1.1 percent per year to 2000 and 0.8 percent thereafter. The Second Appraisal used average increases ranging from 1.0 percent per year to 2.6 percent per year (alfalfa and soybeans, respectively) to the year 2000, and from 0.7 percent per year to 1.2 percent per year (alfalfa and feedgrains) thereafter (fig. 85). These differences in annual rates of change would have a considerable effect on yields over 50 years.

In spite of the collapse in the export market in the early 1980's, projected export demands are higher in the Second Appraisal than the First. Projected domestic demands for many crops are lower, however, in the Second Appraisal than the First. Projections of total demand for corn and wheat, therefore, are at about the same levels in both appraisals. Projected demands for sorghum grain and soybeans are higher in the Second Appraisal, and projected demands for all other major crops are lower than those used in the First Appraisal.

Differences in projections of cropland required to provide feed for livestock account for much of the difference in the two RCA appraisals. The Second Appraisal intermediate scenario projects a 91-million acre net decrease in cropland use between 1982 and 2030. About 65 million acres of that is reduction in acres planted to hay, silage, or feedgrain for livestock. In the Second Appraisal, livestock production and pasture/range forage are sectors of the CARD system, and the model is allowed to project the least-cost forage and least-cost grains that will supply the necessary nutrients, with some substitution of forage for grain permitted. For the First Appraisal, livestock production and feed requirements were based on NIRAP projections, which rely heavily on recent trends.

NIRAP

NIRAP is a systems simulation model that traces its origins tp the early 1970's in ERS. Used originally for the ERS portion of the Water Resources Council's OBERS projections, it has since been under continuous development and is now a key component of ERS' long-run outlook reporting system. NIRAP projections are based on trend extrapolation as modified by long run supply-demand equilibrium equations and resource constraints. NIRAP projections of exports, domestic (nonfeed) commodity demands, and acreages of crops not analyzed by the CARD model were used in both the First and Second RCA Appraisals.

NIRAP projections differ considerably from the CARD projections. A comparison analysis was made to study the extent of the differences. Using identical demand levels and coordinated productivity assumptions, NIRAP projects that in 2030 a total of 387 million acres of cropland would be harvested or in summer fallow, whereas the CARD model projects 276 million acres would be used. (NIRAP was not run for the intermediate scenario; this coordinated analysis differs in some assumptions from the other

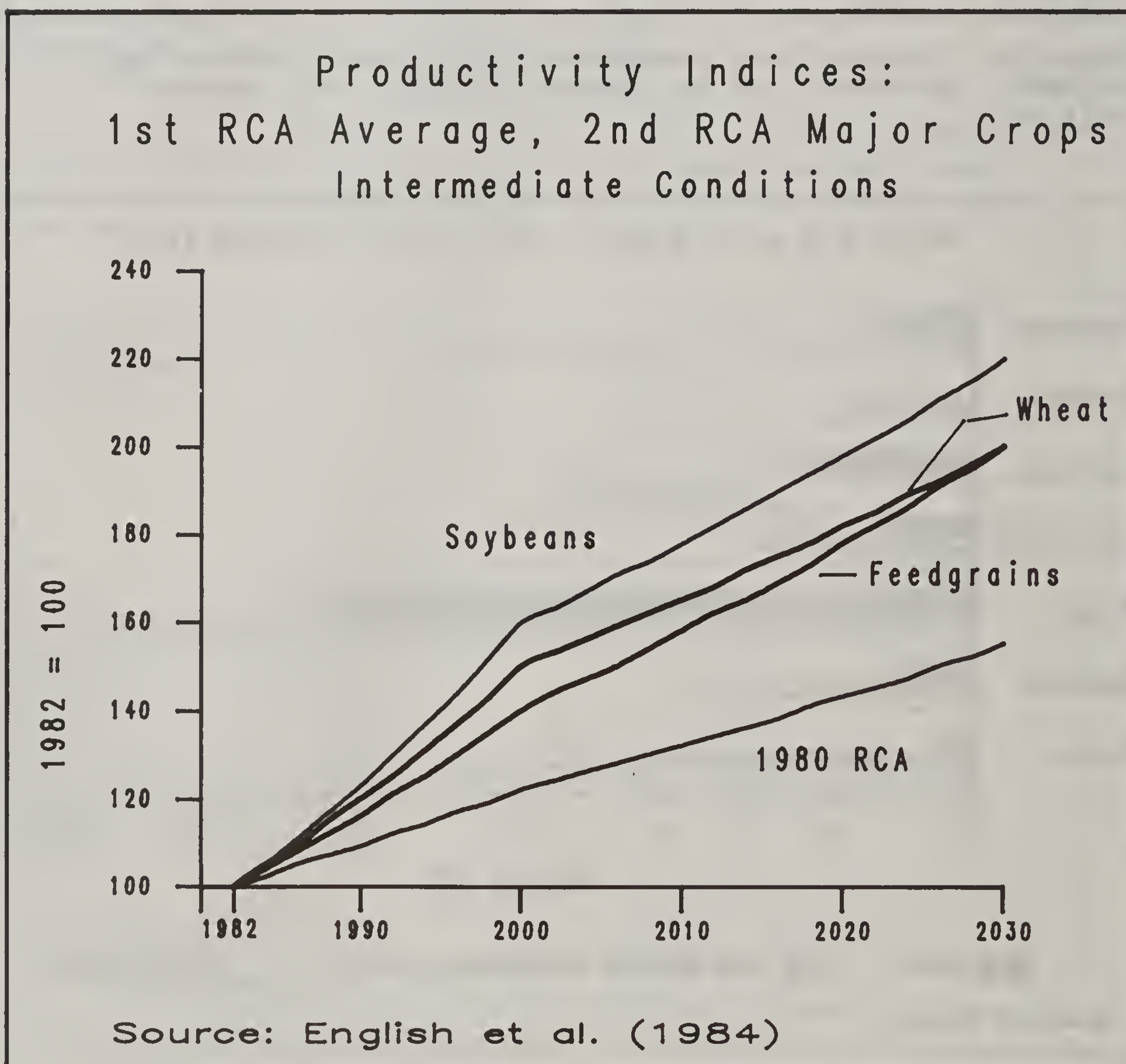


Figure 85.--Projected rates of yield increase, First and Second RCA Appraisals. See appendix tables 56 and 57 for additional data.

analyses reported in preceding pages.)

The NIRAP analysis incorporated the assumption that the acreage of idle cropland in 2030 would not greatly exceed the historical acreage. In addition, NIRAP projects greater production of feedgrains than the Appraisal. NIRAP feedgrain demands are based on historical patterns, assumed demand for animal products, changes in feed use efficiencies, and changes in prices as interpreted by an elasticity matrix; CARD used the same demand and feed use efficiency assumptions but assumes fixed prices and compares the relative cost of nutrients in alternative feeds, including pasture/range forage, to determine the least-cost solution.

NIRAP projects much less use of pastureland and rangeland forage. By 2030, CARD projects utilization of 453 million tons of forage from private pasture/rangeland as a nutrient source; NIRAP projects use of 146 million tons.

Although NIRAP and CARD use identical assumptions of annual rates of yield increase, NIRAP projects lower yields than CARD. NIRAP gives more weight to recent trends in its projections for rates of increase until 1990.

Resources for the Future

A Resources for the Future 10/ study (1982) 11/ projected commodity production and resource use in the United States for 1990 and 2010. This analysis indicated that by 2010, the nation would require 446.9 million acres in crop production--more than double the projections of the Second RCA Appraisal for either 2000 or 2030.

10/ Resources for the Future is an independent organization founded in 1952 that conducts research in the development, conservation, and use of natural resources and on the quality of the environment.

11/ Crosson and Brubaker. Op cit.

Table 56.--Projections of cropland required, selected studies

Analysis 1/	Cropland needed in: 2000	2010	2030
	(million acres)		
2nd RCA Appraisal 2/	218		218
1st RCA Appraisal	386		389
NIRAP			385
RFF (1982)		447	

1/ Analyses use different assumptions about resources availability, demand, and yields.
2/ "Intermediate conditions" scenario.

Table 57.--Projected total demand, RFF study and Second RCA Appraisal

	RFF	Second Appraisal	
	2010	2000	2030
	(million tons)		
Feedgrains 1/			
export	184.1	100.0	163.9
domestic	206.1	177.2	184.6
total	390.2	277.2	348.5
Soybeans			
export	83.8	38.6	70.7
domestic	48.5	43.8	53.8
total	132.3	82.4	124.5
Wheat			
export	77.2	53.4	84.2
domestic	30.9	23.5	25.9
total	108.1	76.9	110.1

1/ Corn, grain sorghum, oats, and barley.

Table 58.--Projected average yields, RFF study and Second Appraisal

	RFF	Second Appraisal	
	2010	2000	2030
	(tons per acre)		
Feedgrains 1/	3.24	3.77	4.73
Soybeans	1.21	1.71	2.00
Wheat	1.19	1.84	2.18

1/ Corn, grain sorghum, oats, and barley.

The RFF analysis assumed export and productivity rates based on experience from the late 1970's. It used higher export demands and lower yield increases than those projected in the Second Appraisal (tables 57 and 58).

Other Projections

Many students of resource use and other analysts have developed projections of crop production and resource use over the past two decades, with markedly varied conclusions. Most support a notion of impending resource scarcity. Included among them are the Club of Rome study of the early 1970's, 12/ the National Agricultural Lands Study (1981), 13/ the work of Martin Abel (1982), 14/ and the Global 2000 report to the President (1980). 15/ The opposite camp includes work by Heady (1982), 16/ The Resourceful Earth 17/ (essentially a rebuttal of Global 2000), and the Second RCA Appraisal.

12/ Meadows, Donella, Dennis L. Meadows, Jorgen Randers, and W.W. Behrens III. 1972. The limits to growth. New York, Universe Books.

13/ United States Department of Agriculture and President's Council on Environmental Quality. 1981. National agricultural lands study. Washington, DC.

14/ Abel, Martin. 1982. Growth in demand for U.S. crop and animal production by 2005. In: Pierre Crosson, ed., The cropland crisis: myth or reality. Johns Hopkins, Baltimore, for Resources for the Future.

15/ The President's Council on Environmental Quality. 1980. Global 2000 report to the President. Vols. I, II and III. Government Printing Office, Washington DC.

16/ Heady, Earl O. 1982. The adequacy of agricultural land: a demand-supply perspective. In: Pierre Crosson, ed., The cropland crisis: myth or reality. Johns Hopkins, Baltimore, for Resources for the Future.

17/ Simon, Julian L., and Herman Kahn, eds. 1984. The resourceful earth: a response to Global 2000. Blackwell, Oxford and New York.

CHAPTER 13
Methods

This chapter describes the major inventories and analytic tools used in the appraisal.

Bibliographies for each report topic are included.

National Resources Inventory (NRI)

The 1982 National Resources Inventory (NRI) covered the nonfederal soil, water, and related resources of the United States. It provided much of the data used in preparing the 1985 RCA appraisal. The 1982 NRI included 49 states and the U.S. possessions in the Caribbean area; a separate Alaskan inventory is under way.

The 1982 NRI was designed by the Iowa State University Statistical Laboratory and conducted by the Soil Conservation Service (SCS) with cooperation from the Forest Service and other federal agencies. Data were collected by census, area sampling, and point sampling methods, and were edited for compatibility and reasonableness at Iowa State University.

For the census method, the most recent census statistics were collected to establish county base data on (1) water areas larger than 40 acres and perennial streams wider than one-eighth of a mile and (2) acreage of federal land. All other land in a county is considered nonfederal rural land, for which area and point sampling data were collected.

Area sampling was used to estimate the acreage of land in various uses and conditions, such as urban and built-up land, farmsteads, critically eroding areas, water bodies, and windbreaks. In this method, each county was divided into strata and a primary sampling unit was selected from each stratum. Nearly 350,000 sampling units were used, roughly 3.5 percent of the nonfederal land area in the United States. Each unit was outlined on an aerial photograph, and data elements were delineated within the sampling area. Delineated elements were measured and validated by field inspection. Measurements were then expanded according to the sampling rate and added to provide state, major land resource area, and national estimates.

Point sampling was used to collect the most detailed information, such as kinds of crops, the extent to which conservation tillage and other conservation practices were used, soil characteristics, treatment needs, and the data needed to determine rates of erosion. Inventory specialists also collected information on prime farmland, wetlands, saline and alkaline areas, and flood prone areas. Points were selected in each sampling unit and onsite data were collected from each point. The data were expanded according to the acreage represented by the points and added to provide state, major land resource area, and national estimates.

The NRI results are basic statistics, not data analyses. They are estimates, not absolute values.

Water Data

National Water Data Exchange (NAWDEX) is a national confederation of water-oriented organizations working together to improve access to water information. The Water Resources Division of the U.S. Geological Survey (USGS) indexes data held by NAWDEX participants to provide a central source of water data. The Water Data Sources Directory identifies over 400 organizations that collect water data; more than 375,000 sites for which water data are available and the geographic location of those sites; types of data, parameters, periods of time, and frequency of measurement for which data are available; and the media in which records are stored. Although it is not the function of NAWDEX to provide data storage and retrieval services for its users, NAWDEX does have direct access to some large water data bases:

- Water Data Storage and Retrieval System (WATSTORE). The USGS collects data at 16,000 stream-gauging stations, 1,000 lakes and reservoirs, 5,200 surface water quality stations, 1,020 sediment stations, 30,000 observation wells, and 12,500 ground-water quality wells. Records stored in WATSTORE files are:

  --surface-water, water-quality, and ground-water data measured daily or continuously,

  --annual peak values for streamflow stations,

  --chemical analyses for surface- and ground-water sites,

  --water-data parameters measured more frequently than daily,

  --geologic and inventory data for ground-water sites, and

  --summary data on water use.

  In addition to storage and retrieval, WATSTORE can provide a variety of products ranging from simple tables to complex statistical analysis.

- Storage and Retrieval System (STORET). The U.S. Environmental Protection Agency (EPA) manages STORET, a system containing over 40 million individual observations of water-quality parameters. Data can be provided as printed tables, statistical analyses, graphic displays, or in a machine-readable form.

- Environmental Data and Information Service (EDIS), Iowa Water Resources Data System (IWARDS), and the Nebraska Natural Resources Information System (NNRIS) are state-governmental organization data banks.

- National Stream Quality Accounting Network (NASQAN). USGS designed the data-collecting network to obtain overviews of the quality of our streams by river basins. NASQAN is one of several data bases designed for a particular purpose that are accessible to NAWDEX users.

Flood Damages: Data Sources

The most comprehensive information on the magnitude and trends of the Nation's flooding problem is published in the Second National Water Assessment, prepared by the Water Resources Council and its member agencies, under the authority of Public Law 89-80. Other sources of data used in this report are the 1977 National Resources Inventory, the National Oceanographic and Atmospheric Administration/National Weather Service (NOAA/NWS), and the National Flood Insurance Program. A regression analysis was made of the NOAA/NWS data to establish trends.

The data for the 1980 appraisal came primarily from the WRC Second National Water Assessment, SCS open file material, and the Federal Emergency Management Agency (FEMA) community flood insurance reports.

New data sources used in this appraisal are the 1982 National Resources Inventory, updated FEMA flood insurance reports, NOAA/NWS flood database material, and SCS open file material from River Basin Study Reports and Public Law 83-566 watershed plans.

National Fisheries Survey

The data on aquatic habitat in this report are derived from the results of the National Fisheries Survey (1982). This survey was conducted jointly by the U.S. Environmental Protection Agency and the U.S. Department of the Interior, Fish and Wildlife Service. It was based on a statistically selected sample of 1,303 river segments across the country which represented all flowing waters in the conterminous 48 states, including main-stem impoundments. The survey excluded the Great Lakes, estuaries, coastal waters, and wetlands. The waters thus defined amount to 955,155 stream miles, of which about 69.8 percent (666,518 miles) are perennial streams.

State fish management experts, who averaged 9 years of experience in the selected cataloging units or watersheds, were queried. Forty percent of the reaches had been quantitatively or qualitatively sampled, and sampling had been done in surrounding cataloging units for an additional 33 percent. Twelve hundred and eighty-five questionnaires, 98.5 percent of the total distributed, were completed and returned.

Survey respondents were asked to provide information on four basic issues: the fish species occurring in each reach, the time of year during which the segment is usable as fish habitat, conditions adversely affecting fish in the reach, and trends in reach conditions. The respondents also described kinds of fisheries data available for the reach.

Estimating Erosion

Sheet and rill erosion.--Sheet and rill erosion is estimated by the Universal Soil Loss Equation (USLE). The equation is: A = RKLSCP. In this equation, the soil loss, A, is expressed as a function of factors that represent the physical and climatic conditions of a specific site and factors that represent what the farmer is doing on that site. The factors that represent the physical and climatic forces of the site, if considered alone, estimate the sheet and rill erosion that could theoretically occur on the soil if it were in continuous clean-tilled fallow. Physical and climatic factors in the USLE are the erosive force exerted by rainfall and runoff (R), the degree to which the soil resists those forces (K), and the length and steepness of the slope of the soil, represented by a nonlinear factor (LS). The K factor is an estimate of the inherent erodibility of a soil, and the R, L, and S factors refine that rating to provide an estimate of the soil's erodibility under specific climatic conditions at a specific topographic site. The C and P factors estimate the degree to which use and management of the soil reduce erosion. The C factor represents the protection against erosion provided by the crop and tillage system, and the P factor represents the protection afforded by the supporting practices of contouring, strip-cropping, and terracing.

In spite of its title, the USLE measures soil movement within a field, not soil loss from the field. In many places and many years, very little of the soil moved by sheet and rill erosion leaves the field. Measurements in numerous watershed studies have showed that the amount that actually leaves a watershed ranges from 10 to 100 percent of the eroded soil as estimated by the USLE, with the most common values being around 40 percent. How much is lost depends on the nature of the soil, the slope characteristics of the landscape pattern, and the transport efficiency of the stream system. Damages caused by soil when it leaves a field are discussed in chapter 9 of this report.

The USLE does not estimate all soil moved by water. The USLE was developed through the analysis of data from many years of experiments, mainly on standard erosion plots that were about 73 feet long with a slope gradient of about 9 percent; some plots of greater length and different or varying slope gradient were also included. To give results from which useful generalizations could be made, the erosion plots were designed to minimize the effect of factors other than the five that were being studied. The plots, for example, were straight, and the small topographic irregularities that occur in most fields were carefully eliminated. But these irregularities strongly influence erosion, causing erosion in some places and deposition in others. Further research and computer modeling suggest that irregularities in the microtopography of the land may have as much influence on the amount and effect of sheet and rill erosion as slope gradient and slope length.

Gully erosion.--Estimating ephemeral gully and classic gully erosion is a difficult and lengthy process. Ephemeral gullies form in cropland where converging sheet and rill runoff concentrates and begins to cut deeply into the soil. Ephemeral gullies are shallow enough to be tilled over but new and gradually deeper channels form in the same area after every storm. The soil moved by ephemeral gully erosion is not included in USLE-estimated erosion data because the standard experimental plots from which the USLE was developed were much shorter than most fields and not long enough to allow flow to concentrate into deeper channels. Studies on the effects and extent of ephemeral gullies have been made, and techniques for estimating erosion from them will soon be developed.

Classic gully erosion removes large amounts of soil. If the subsoil in a gullied area is deep and has weak structure, the banks of gullies may slough and cave in. As water continues to flow down the gullies, masses of soil break loose and are swept downstream. Processes leading to the formation of gullies are not completely understood; both geological

processes and management practices play a part. Predictions can be made only on the basis of detailed studies at specific sites, and available methods are expensive and time-consuming. The onsite damage resulting from gully erosion is measured not so much in tons of soil lost as in the loss of arable land. Gully erosion also results in sedimentation downstream, reducing channel capacity and leading to increased flooding.

Wind erosion.--Wind erosion is estimated by the Wind Erosion Equation (WEQ). The equation is E = f(IKCLV). Soil loss, E, is expressed as a function (f) of the physical and climatic conditions of soil erodibility (I), climate (C), and field length (L) (field length, unlike I and C, can be altered by management) and two management factors, the vegetation density factor (V), and soil (surface) roughness (K). The f indicates that this equation involves relationships that are non-linear.

In wind erosion, the coarser soil particles "jump" along the soil surface (a process known as "saltation"). In doing so, they may damage crops and accumulate as dunes in neighboring fields or roads. The finer particles and aggregates are carried off as dust and may move long distances.

Wind erosion has been studied much less extensively than water erosion, in part because its economic significance was not fully recognized and in part because wind erosion is much more difficult to study and measure. Also, wind erosion is influenced more by variables, such as the moisture content of the upper part of the soil during windy periods, or whether or not the soil's surface has a crust. Most research on wind erosion has made use of wind tunnels, which provide only an imperfect approximation of natural conditions.

Erosion/Productivity Impact Calculator (EPIC)

Response to the Resources Conservation Act of 1977 cited the need to study the effects of erosion on soil productivity. As a result, a team of Agricultural Research Service (ARS) scientists developed the Erosion/Productivity Impact Calculator (EPIC) model, first reported operational in May 1985.

EPIC is a physical-process model that simulates interaction of the soil-climate-plant management processes in agricultural production. The model is composed of physically based submodels capable of simulating plant growth and related processes when constrained by erosion. The components of EPIC include hydrology, weather, erosion-sedimentation, nutrient cycling, plant growth, tillage, soil temperature, plant environment control, and a financial component, which is a simple accounting of costs and returns. Each submodel has subroutines that are linked sequentially and interactively to estimate the change in soil characteristics as erosion continues over a given period.

EPIC operates on daily time steps that estimate daily erosion, crop yield, fertilization, irrigation, plant stress, runoff, and many other factors. The model estimates the accumulated effect of soil erosion on inherent soil productivity by reducing the thickness of the root zone and the soil's moisture-holding capacity. EPIC includes in its simulations the changes in texture and chemical properties as subsoil becomes mixed with topsoil in the plow layer, the loss of nutrients through removal of sediment, accelerated runoff, and changes in toxicity in the root zone. The model assumes constant management and technology throughout the simulation period but simulates daily variations in weather.

EPIC was designed to utilize data available in the early 1980's. Its design allows for expansion and inclusion of later research in soil-climate-plant processes. EPIC is a point source model with limited reliability on areas greater than 10 square meters (maximum size of a pedon).

EPIC does not estimate or take account of all the ways in which erosion can impair productivity. Some of the effects not considered in the simulations reported here are: damage to plants by wind erosion or by deposition; failure of seedlings to emerge because of crust formation on eroded soils; death of plants affected by drought, where the soil's capacity to absorb and hold water has been reduced by erosion.

Erosion/Productivity Index Simulator (EPIS)

The Erosion/Productivity Index Simulator (EPIS) model was developed to provide a systematic method for analyzing EPIC output. EPIS was used to index 12,000 individual EPIC simulations into values that estimate the effects of erosion at the MLRA, state, and national levels. The EPIS output estimates relative soil productivity among RCA land groups, tillage practices, and crops. EPIS also estimates the additional fertilizer requirements over time due to fertility lost through erosion.

Other Erosion/Productivity Models

USDA has tested two other models to estimate the effects of erosion on productivity. The yield/soil loss simulator (Y/SL), the first of these models, was developed for the 1980 RCA appraisal. Using regression analysis, a relationship between crop yield and past erosion was computed as a function of soil depth based on expected erosion. The equations in the Y/SL assumed constant technology and management, just as EPIC does. Because the data used in the Y/SL system were published over a long period of time, some of the data were not comparable, as those in a regression framework must be, and normalizing procedures were needed.

The Productivity Index (PI) model starts from the hypothesis that the major effect of erosion is to change the soil's micro-environment for root growth, thus affecting crop yields. The PI calculates the relationship between erosion and changes in the soil properties that determine the soil's capacity to support root growth--available water capacity, bulk density (adjusted for permeability), and pH. On most soils, the PI goes down as the lower layers of a soil are incorporated into the plow

layer. The PI has performed well in tests for the Corn Belt, using corn as the crop. It is being tested in other regions of the country.

Interactive Conservation Evaluation (ICE)

The Interactive Conservation Evaluation (ICE) program was designed to provide soil conservationists with an automated evaluation process for assisting land users in evaluating and selecting alternative soil conservation measures for their farming operations. The data for input consist of variables associated with farmland's physical and economic resources and factors involved with the installation of resource management systems. This includes such things as soil series, land use, cost of crop production, interest rate, installation cost of conservation practices, cost share rate, etc. ICE produces results on many alternative resource management systems for each field of a farming operation. These results include a summary of erosion rates, gross and average annual returns, crop yield reductions resulting from excessive erosion, and benefits accruing from conservation practices that conserve soil moisture. With these results a land user can evaluate the physical and economic results of implementing alternative conservation measures on eroding land and select the alternative that best suits his/her goals.

Water Network Model

The Resources for the Future (RFF) Water Network Model estimates the effects of point and nonpoint pollution on representative water bodies throughout the United States. The network of water bodies covered includes 304 rivers, 175 lakes and reservoirs, 37 bays, 10 segments of Great Lakes shoreline, and 26 segments of ocean shoreline.

The data base used in this water network model is the RFF Environmental Data Inventory, which estimates discharges of 17 pollutants from approximately 20,000 point sources and an equal number of nonpoint sources. In addition, there are more than a million records describing crop-specific pesticide use at the county level. Point source pollutants enter the model at one or more of the network's 1,300 nodal points, and nonpoint source pollutants enter evenly between adjacent nodal points. The assignment of nodal points is based on U.S. Geological Survey runoff maps.

Once pollutants enter the water network, the model estimates their transport, dilution, and decay. These are functions of the pollutant's physical characteristics and the characteristics of the receiving water (velocity, flow, channel cross section, slope, and other factors). The model can estimate concentrations of pollutants at any location and for any water body in the system. Generally, results are reported for nodal point locations, which often coincide with the locations of USGS monitoring stations, permitting model verification with monitored data.

In principle, concentration estimates can be provided for all 17 pollutants. The current model, however, estimates only the concentrations of dissolved solids, biochemical oxygen demand, dissolved oxygen, total phosphorus, and Kjeldahl nitrogen. Sediment concentration relationships are being developed.

Because the RFF model provides estimates of water quality in specific bodies of water, it is useful in analyzing comprehensive national policies affecting water quality.

Wildlife Habitat Assessment Model

The 1985 adaptation of the RCA wildlife appraisal model analyzes actual versus potential habitat diversity. The model uses habitat data available from the SCS National Resources Inventory.

The appraisal model is based on two assumptions: that the habitat suitable for a particular species satisfies the breeding and feeding needs of that species; and that habitat characteristics directly influence the number of different species and the population of each species within a region.

To develop a habitat structure index, the acreage of potential wildlife habitat for a specified area of analysis is determined by subtracting the acreage not suitable for habitat (mainly urban or built-up land). For this analysis, habitat is divided into seven layers: water column (deep water), water surface (wetland), ground subsurface, ground surface, shrub or midstory, tree bole, and tree canopy. These seven layers are the main components of the landscape used by wildlife species for breeding and feeding.

The model produces an index that compares existing habitat diversity with that which would be present under natural, undisturbed conditions (index value of 1.00). The index is based on the number of layers present and a rating of the quality of vegetation within each layer. The index value of a given habitat is a measure of how much that environment has been modified by human activities.

Center for Agricultural and Rural Development (CARD) Linear Programming Model

The CARD linear programming model, developed by Iowa State University's Center for Agricultural and Rural Development, analyzes the effects of various practices and conditions on the Nation's agricultural land base and selects the least costly method of achieving a given level of production. Constraints on resources available, conservation requirements, and the effects of new technology can be built into the model, which chooses activities that best meet a specific criterion.

Expanded from an earlier version, the model includes livestock production, pasture and range, and private forests as well as cropland. The crop sector includes recent production cost data and a means for analyzing erosion-productivity-fertilizer relationships estimated by the Erosion Productivity Impact Calculator (EPIC).

The model allows for regional adjustments in climate, soil, and

farm structure. It restricts the availability and use of resources and commodity production, processing, and transportation to levels that are realistic given the resource base, commodity demands, and infrastructure of a particular region. It uses transportation networks to balance demands and resource interactions among regions.

Analysts have used the results of the CARD model to assess the impact on the resource base of erosion, conservation goals, and the costs of production from 1990 to 2030.

National-Interregional Agricultural Projection Model (NIRAP)

The National-Interregional Agricultural Projection (NIRAP) model is used by the Economic Research Service to make projections of the U.S. agricultural sector. The model produces yearly estimates of supply and demand for 31 crops and animal products on a national and state basis. NIRAP allocates production of each commodity to the 50 states on the basis of projected resource availability. Future changes in supply and demand relationships are estimated on the basis of macro-economic variables, such as increases in population and advances in technology.

The NIRAP projections of food and fiber demand are used in the CARD linear programming model.

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APPENDIX A:
Land Use Data

The following pages present definitions and basic statistics on land use not presented elsewhere in this report. Much of the information was collected for the 1982 National Resources Inventory (NRI). Some data from other sources also are included.

The 1982 NRI was conducted on nonfederal land by the USDA Soil Conservation Service. The data collection methods are described in the preceding chapter of this report.

The total surface area of the United States (including the Caribbean and Hawaii but excluding Alaska) is 1,940,060,100 acres, according to the 1982 NRI. Of this, about 77 percent is owned by private citizens, by businesses and industries, and by states, counties, cities, and other units of nonfederal government. About 21 percent is administered by the federal government. About 2 percent is large areas of water of more than 40 acres (defined as water by the Bureau of the Census).

The status of federal land is described in the report prepared by the USDA Forest Service under the terms of the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA).

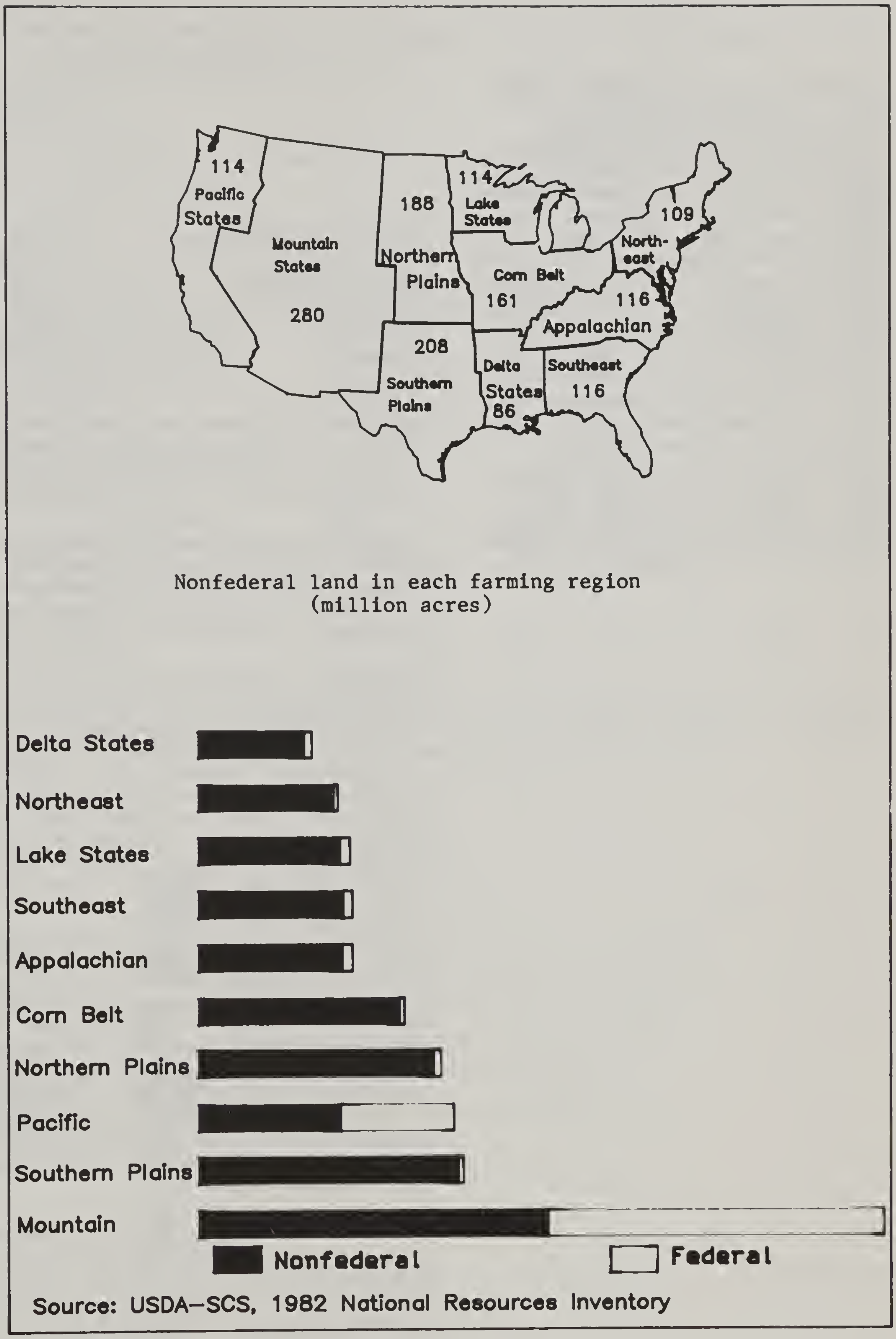


Figure 86.--Federal and nonfederal land in the farming regions. For additional data, see appendix table 2.

Adjusted Land Use Data

Data gathered on nonfederal land by SCS and those compiled by the USDA Forest Service on federal land are not compatible because the two agencies use different definitions for some plant communities that include grasses, shrubs, and trees. The two agencies are attempting to resolve these differences so that data collected by the two agencies can be combined to present a comprehensive study of all the Nation's soil and water resources. Table 59 shows the acreage of both federal and nonfederal land according to the definitions agreed to in 1982. Definitions shown, except "transition land," also are used in the 1982 NRI. The table includes data for Alaska that are not included in the NRI.

Table 59.--Use of federal and nonfederal land in the United States

	Nonfederal land	Federal land	Total
	(1,000 acres)		
Crop and pasture land	529,851		529,851
Rangeland	441,466	328,887	770,353
Transition land	35,603		35,603
Forest land	409,284	276,417	685,701
Other land	159,776	73,504	233,280
Total	1,575,980	678,808	2,254,788

CROPLAND--Land used for the production of adapted crops for harvest, alone or in rotation with grasses and legumes. Adapted crops include row crops, small grain, hay, nursery crops, orchard and vineyard crops, and other similar specialty crops.

PASTURELAND--Land used primarily for the production of adapted, introduced, or native species in a pure stand, grass mixture, or a grass-legume mixture. Cultural treatment in the form of fertilization, weed control, reseeding, or renovation is usually a part of pasture management in addition to grazing management.

RANGELAND--Land on which the climax vegetation (potential natural plant community) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing and browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundra, and certain forb and shrub communities. It also includes areas seeded to native or adapted introduced species that are managed like native vegetation. Federal rangeland includes 40,663 million acres administered by the USDA Forest Service, 201,294 million acres administered by the Bureau of Land Management, and 86,930 million acres administered by other federal agencies.

TRANSITION LAND--Land that meets the definition of forest land based on cover characteristics but where the predominant vegetation is grasses or forage plants that are used for grazing. The Soil Conservation Service has classified most of these lands as rangeland; the Forest Service has classified these lands as forest land. In most instances, these lands are noncommercial timberland ecosystems such as pinyon-juniper, chaparral, and post oak. Transition land is an interim category; the Forest Service and Soil Conservation Service will resolve classification differences and show all such land as rangeland or forest land in future reports. Some of the area in these noncommercial timberland ecosystems is classified as forest and range land in this report.

FOREST LAND--Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use. The minimum area for classification of forest land is 1 acre and must be at least 100 feet wide. Forest land is distinguished from rangeland in transition vegetation types if the tree canopy cover exceeds 10 percent. Forest lands include cutover areas temporarily unstocked as well as young stands and plantations established for forestry purposes which do not yet have 10 percent crown cover.

OTHER LAND--A category of land cover and land use that includes farmsteads, other land in farms, stripmines, quarries, gravel pits, borrow pits, permanent snow and ice, small built-up areas, and all other land that does not fit into any other land cover or land use category.

Source: USDA Forest Service and Soil Conservation Service.

Nearly 28 percent of all nonfederal land is used as cropland. About two-thirds of cropland is planted to four crops (fig. 87). Table 60 shows the average yield per acre on irrigated and nonirrigated land for some major crops. Actual yields vary widely on different soils, and average yields vary among regions.

Table 60.--Irrigated and nonirrigated yield per acre for specified crops, 1978 and 1982

		Average yield per acre			
		1978		1982	
Crop		Irrigated	Non irrigated	Irrigated	Non irrigated
Corn for grain or seed	(bushels)	114.3	94.9	122.1	106.0
Corn for silage	(ton, green)	17.7	12.6	19.3	13.0
Sorghum for grain	(bushels)	71.3	48.1	78.0	53.6
Wheat for grain	(bushels)	71.3	48.1	78.0	53.6
Barley for grain	(bushels)	54.7	28.5	64.3	31.8
Rice	(cwt)	44.5	-	47.9	-
Soybeans for beans	(bushels)	29.6	28.1	34.1	30.7
Dry edible beans, excluding dry limas	(cwt)	16.8	10.6	17.2	12.3
Cotton	(bales)	1.2	0.7	1.7	0.9
Irish potatoes	(cwt)	295.0	185.6	310.2	183.2
Sugar beets for sugar	(tons)	21.4	18.5	22.8	17.9
Alfalfa hay	(tons, dry)	3.9	2.6	4.1	2.7
Tame hay other than alfalfa and small grain	(tons, dry)	2.0	1.7	2.0	1.8
Wild hay	(tons, dry)	1.3	1.1	1.4	1.2

Source: Dept. of Commerce, Census of Agriculture - 1982 U.S. Summary, Table 40; and 1978 Irrigation, Table 15.

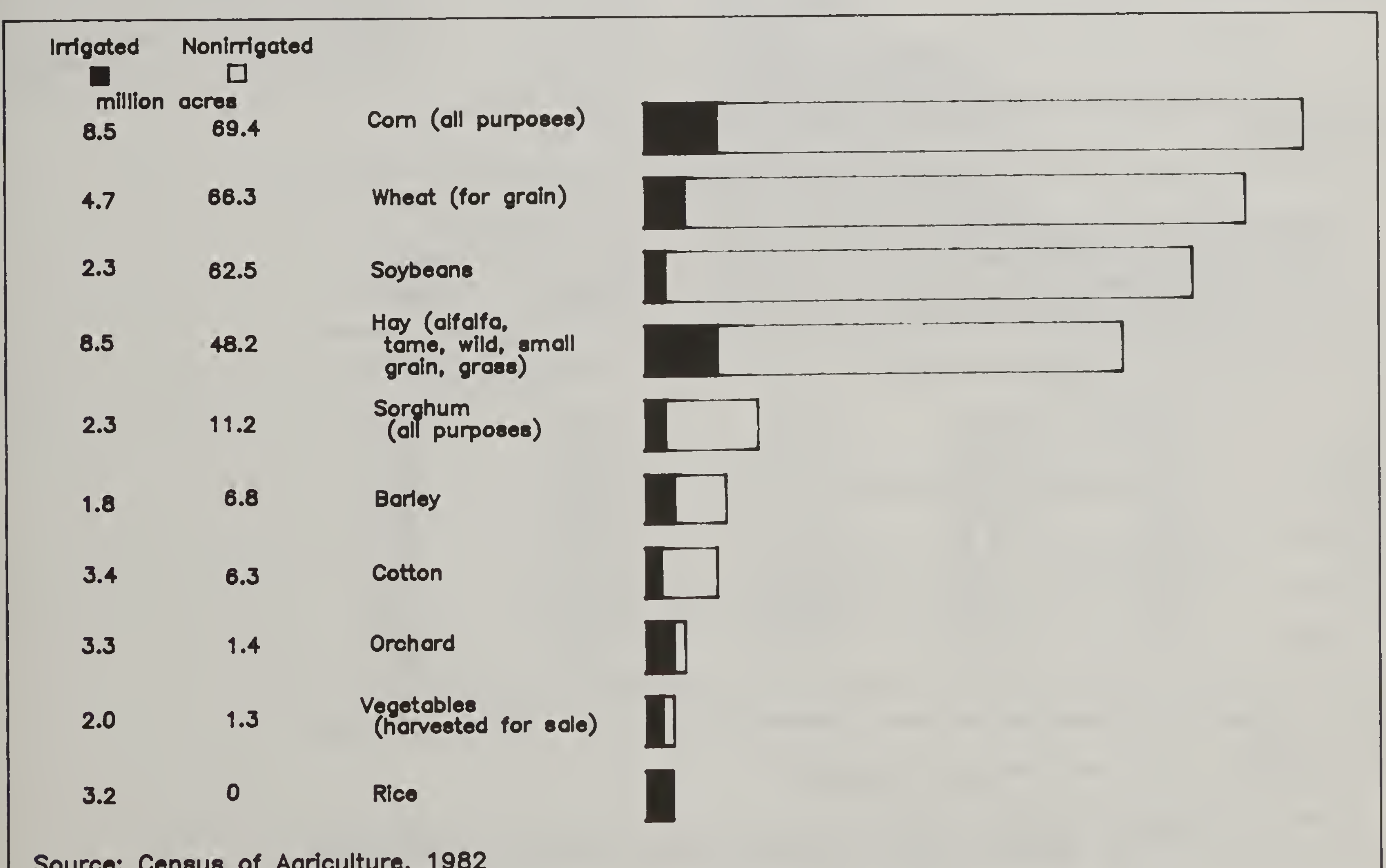


Figure 87.--Acreage of major crops, irrigated and nonirrigated.

Cropland is not evenly distributed across the Nation (fig. 88 and table 61). Texas has more acres of cropland than any other state; Iowa has the highest percentage of its land in crops (74 percent). Cropland is an important land use in all regions, making up more than 10 percent of the nonfederal land in all regions except the Mountain States.

Table 61 shows the crop value per acre, for selected crops, on irrigated and nonirrigated land in each region. Receipts are larger on irrigated land because yields are higher or quality is higher or because different crops are grown. For the Nation as a whole, crop sales average about $145 per acre from nonirrigated land and about $280 per acre from irrigated land. Net profits average about $25 per acre higher on irrigated farms than on nonirrigated farms. For some regions, the value of returns on irrigated land shown in the table is low because high-return vegetable and orchard crops are not included.

Figure 88.--Percentage distribution of the Nation's cropland among farming regions.

Table 61.--Irrigated and nonirrigated cropland, acres and crop value per acre, by farming region

Region	Acreage			Crop value 1/	
	Irrigated	Non-irrigated	Total	Irrigated	Non-irrigated
	----------(million acres)----------			----(dollars/acre)----	
Northeast	0.3	16.9	17.2	380	230
Southeast	3.1	15.1	18.2	300	175
Delta States	5.2	16.8	22.0	255	170
Pacific States	12.2	10.4	22.6	400	160
Appalachian	0.4	22.3	22.7	305	200
Mountain States	14.8	28.4	43.2	220	100
Lake States	1.1	42.8	43.9	320	185
Southern Plains	10.5	34.4	44.9	280	135
Corn Belt	1.2	91.2	92.4	315	220
Northern Plains	11.2	82.1	93.3	240	110

1/ Composite acreage of selected crops: corn, sorghum, wheat, oats, barley, soybeans, cotton, and hay.
Vegetables, orchards, rice, and pasture are excluded.

Source: Acres--1982 National Resources Inventory.
Crop value--1985 RCA Appraisal water data work group, April 1985, unpublished.

Most cropland is in land capability class II or higher, therefore it has some limitations to use. (Refer to chapter 2 for an explanation of land capability classes.) Figure 89 shows the major limitations to use of cropland in the Nation and in each farming region. As the figure shows, susceptibility to erosion is the main limitation on more than half of the Nation's cropland. In addition, erosion is also a hazard on some land where the primary limitations are considered to be wetness, climate, or characteristics of the root zone. Erosion is a hazard on 52 percent of the cropland soils in subclass w, about 70 percent of those in subclass s, and 89 percent of those in subclass c. Climatic conditions are considered the major limitation to use of only a small portion of the Nation's cropland. There are, however, millions of acres of cropland where climatic conditions are similar to those of soils assigned to the c subclass but where other factors are considered the dominant limitation. A climatic limitation--periodic drought--affects crop production and management on most of the cropland in the western United States.

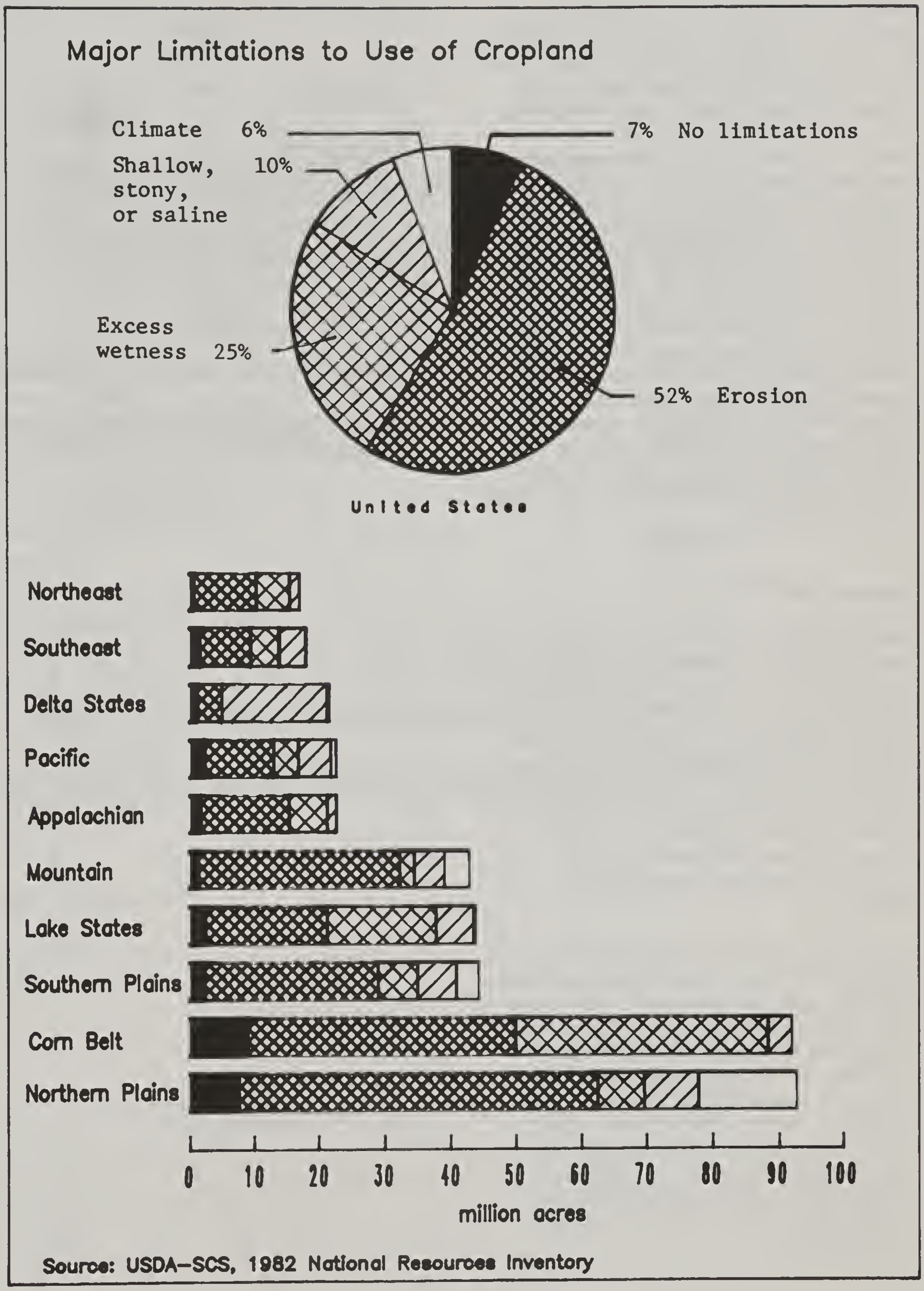


Figure 89.--Major limitations to use of cropland. For additional data, see appendix tables 1 and 3a.

About 43 percent of nonfederal land (excluding Alaska) is producing forage (fig. 90). Forage land includes pastureland, rangeland, grazed forest land, and hayland.

The distribution of pastureland and rangeland is tied primarily to climate and soils. A relatively distinct climatic line exists along the 96th meridian (fig. 91). East of the meridian, lands that are unsuitable for cultivation because of soil limitations generally yield the highest returns if established to well-managed pasture. West of the meridian, most grassland is rangeland because native plants survive better and produce more forage than introduced species will unless the land is irrigated.

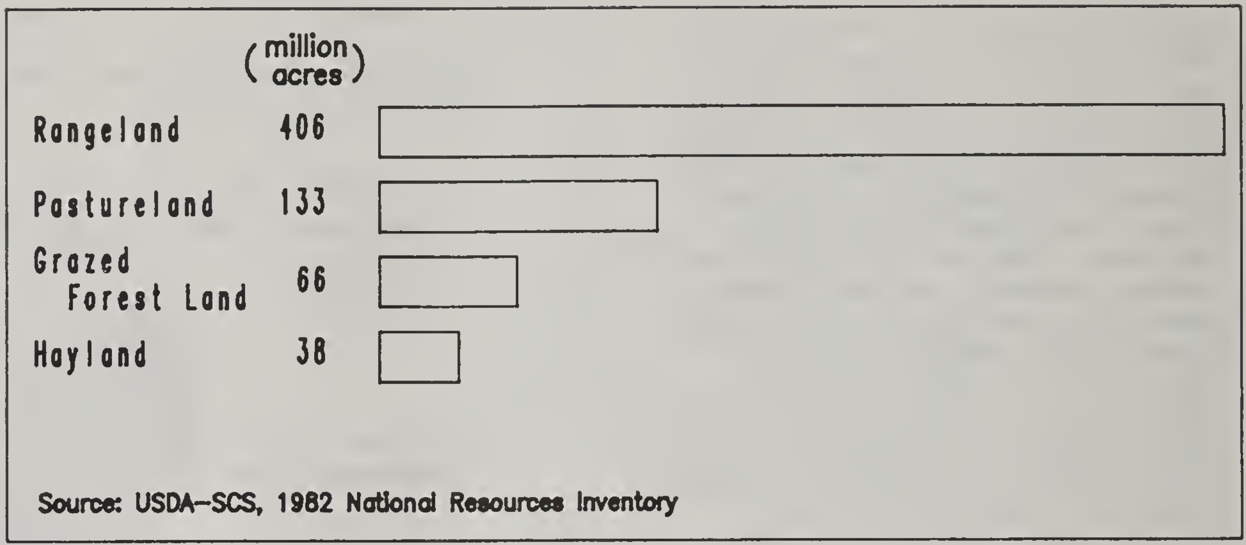


Figure 90.--Acreage producing forage, by type of forage land, million acres. For state data, see appendix table 2.

Pastureland

Pastureland is land that supports introduced or domestic forage plants that respond significantly to management. Native pasture is land on which the natural potential or climax vegetation is trees, but which is used primarily for production of native herbaceous forage plants. In this report, "pastureland" includes both pastureland and native pasture.

Soils in capability classes I through VI are considered suitable for use as pastureland. On these soils, management techniques can be properly applied for high production of introduced species. Soils in capability classes VII and VIII have limitations that prevent adequate management of introduced species. About 10 million acres of land in those two classes are currently used as pasture.

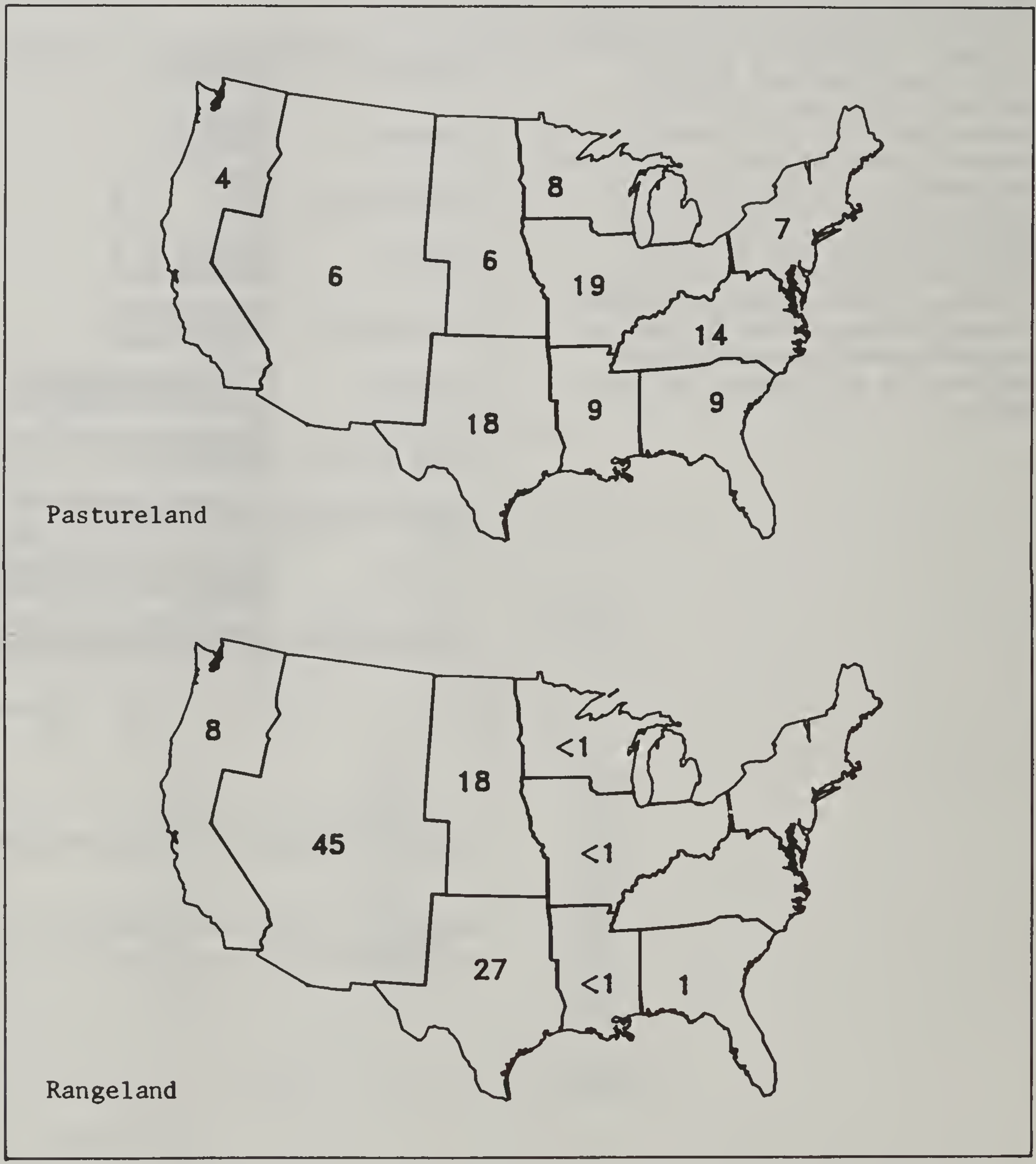


Figure 91.--Percentage distribution of nonfederal pastureland and nonfederal rangeland among farming regions. For state data, see appendix table 2.

Figure 92 shows major limitations to the use of nonfederal pastureland. About 26 million acres of pastureland are affected to some degree by wetness. Wetness affects species adaptation, grazing management, and operations such as fertilizing. About 18.8 million acres of pastureland have limitations in the root zone. Limitations in the root zone affect productivity, species adaptation, and use of equipment.

On some steep slopes, erosion is a hazard. Runoff can be a serious problem in pastures. Studies indicate that there is substantial runoff from many pastures in midsummer when the moisture supplies are limited. Much of this water loss is caused by overgrazing or by soil compaction.

There are three pastureland condition ratings: good, fair, and poor (fig. 93). "Good" means that the best suited plants are being used. There is a moderate to high level of fertility and good to excellent management of grazing. Grazing is at an intensity that results in maximum plant production and vigor. "Fair" means that a moderate level of management is being used. The plants are adapted to the climate and soils but are not necessarily the best for the designated use. Grazing is at an intensity that limits production. Erosion is minimal. Fertilization is irregular and unplanned. A continuous grazing system is in use. "Poor" indicates that the pasture is not properly used or the level of management is low or that the plants are not well suited to the climate and soil. The soil has a low fertility level and evidence of erosion. Brush may be a problem.

Pasture condition ratings are not applicable on land in native plants that are not routinely fertilized, overseeded, or irrigated.

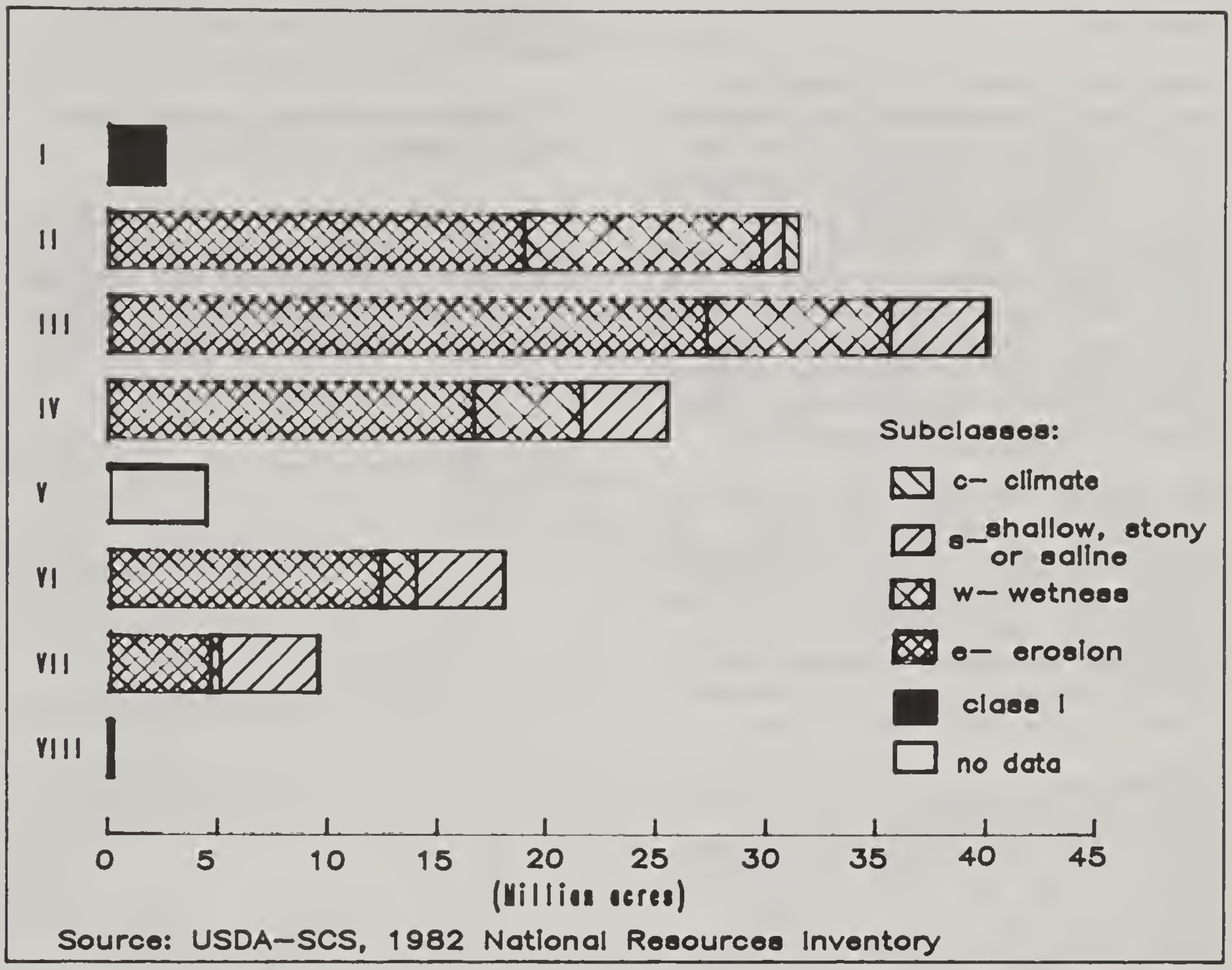


Figure 92.--Major limitations to use of nonfederal pastureland. For additional data, see appendix tables 1 and 3b.

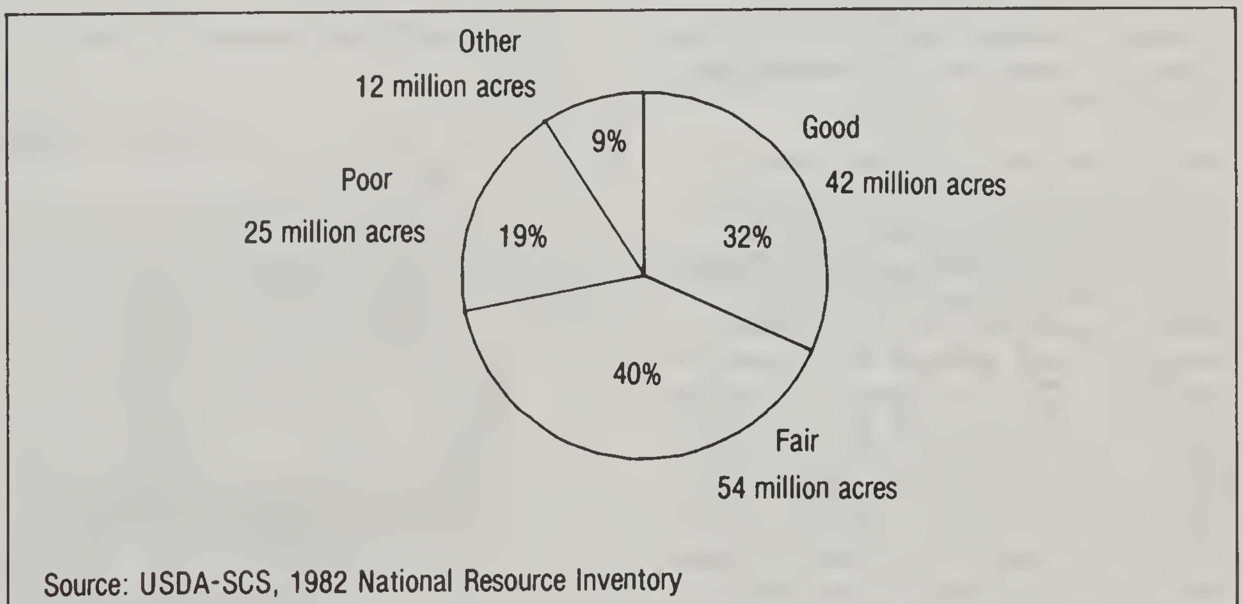


Figure 93.--Condition of nonfederal pastureland.

Rangeland

Rangeland quality is judged by comparing the present vegetation to the climax vegetation for the site. The climax plant community for a site is the combination of species that has evolved over time and is best suited to exploit the soil, moisture, temperature, and other environmental conditions of that site. It is the most productive natural plant community the site is capable of supporting.

The amount of forage provided by the climax community varies widely; average annual production may range from a low of 200 pounds of air-dry material per acre in the arid Southwest to more than 12,000 pounds per acre on marsh sites in the Gulf Coast area.

The degree to which the kinds and proportions of plants in the existing plant community resemble those of the presumed climax vegetation for the site is called range condition. There are four range condition classes: excellent, good, fair, and poor. Excellent condition means that more than 75 percent of the present plant community is climax; good, 50 to 75 percent; fair, 26 to 50 percent; and poor, less than 25 percent (fig. 94). Range condition ratings are not applicable on land seeded to non-native grasses. Range condition is discussed in more detail in chapter 5 of this report.

Grazing by domestic livestock is the dominant use of most rangeland. In fact, grazing is the only feasible means of harvesting the production on most areas. About 93 percent of nonfederal rangeland was grazed by livestock in 1982. This included 24 percent temporarily deferred from grazing during the data-gathering period. Fifty-one percent was judged to be lightly to properly grazed, and 18 percent was overgrazed. Rangeland is considered to be overgrazed when more than 50 percent of the annual growth of management species is removed by grazing animals. Red meat, wool and mohair, and milk are the principal end products of range grazing. Leather, pharmaceuticals, and many other by-products of animal slaughter are also valuable derivatives of range vegetation.

Rangelands provide many other benefits:

o Habitat for many species and large numbers of wildlife.

o A large reservoir for moisture storage. Proper range management enhances infiltration and storage of rainfall and snowmelt. Some of this soil moisture returns to the surface through seeps and springs, feeding rivers and streams.

o Sites for recreation.

o Firewood and several specialty wood products are harvested from shrubby range plants; other range shrubs are popular urban landscape materials.

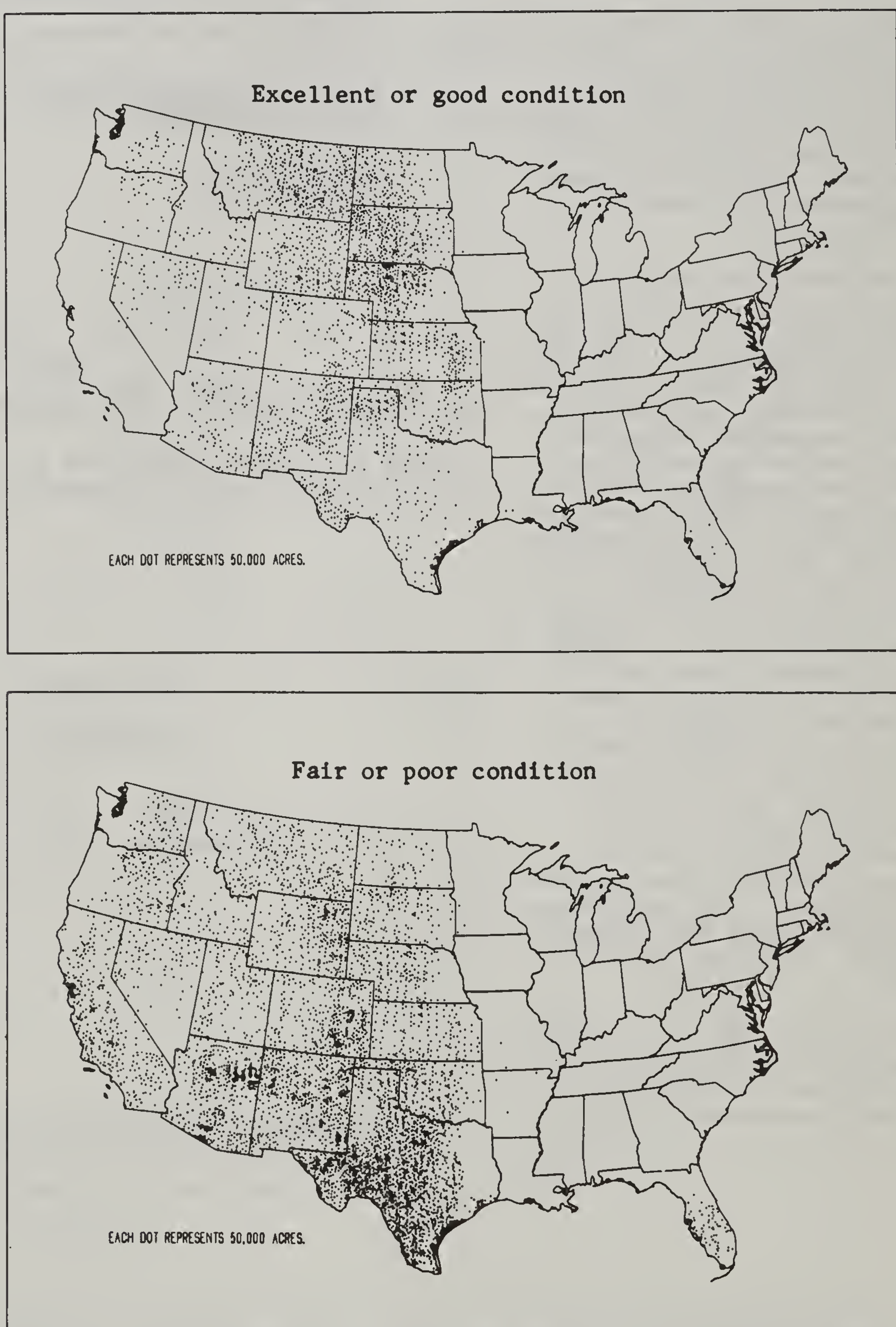


Figure 94.--Range condition on nonfederal rangeland. For state data, see appendix table 33.

Nonfederal forests grow on 394 million acres (fig. 95). Nonfederal forest land provides wood, water, wildlife habitat, herbage, and recreation. Seventeen percent is grazed. Nonfederal forest land is mainly under private or corporate ownership, but some is state and municipal land.

A wide variety of major forest-cover types occurs within each geographic region (table 62). In the Pacific and Mountain regions, Douglas-fir, ponderosa pine, fir-spruce, and hemlock-Sitka spruce are dominant cover types. In the North, oak-hickory, maple, beech, birch, spruce-fir, and elm-ash-cottonwood are the chief cover types. In the South, oak-hickory, loblolly-shortleaf pine, oak-pine, and oak-gum-cypress dominate. These forest-cover types are defined by the USDA Forest Service.

Table 62.--Major forest-cover types on nonfederal forest land, by geographic area

North	South	Rocky Mountain and Pacific Coast
White-red-jack pine	White-red-jack pine	Douglas-fir
Spruce-fir	Longleaf-slash pine	Ponderosa pine
Loblolly-shortleaf pine	Loblolly-shortleaf pine	Western white pine
Oak-pine	Oak-pine	Fir-spruce
Oak-hickory	Oak-hickory	Hemlock-Sitka spruce
Oak-gum-cypress	Oak-gum-cypress	Larch
Elm-ash-cottonwood	Elm-ash-cottonwood	Lodgepole pine
Maple-beech-birch		Redwood
Aspen-birch		

Source: USDA Forest Service.

Figure 95.--Acreage of nonfederal forest land in each farming region. For state data, see appendix tables 1, 2, and 3d.

APPENDIX B: Water Data

This appendix reports data on water supply and water use on which the analyses in earlier chapters of this report were based.

The Hydrologic Cycle

About 40,000 billion gallons of water per day (bgd) pass over the conterminous United States as water vapor. Of this, about 4,200 bgd fall as precipitation on the conterminous United States. If spilled evenly over the Nation's surface, this would represent an average annual precipitation of 30 inches. About two-thirds (2,800 bgd) of the 4,200 bgd returns to the atmosphere through transpiration by plants, evaporation from water and wet surfaces, and absorption of vapors. The remaining 1,400 bgd replenish ground water and surface water supplies (fig. 96).

People withdraw 360 bgd from replenishable supplies and 20 bgd from ground water in excess of natural recharge. An estimated 105 bgd are consumptively used -- that is, they return to the atmosphere, or are incorporated into products, or percolate beyond the area of reuse. The rest flows beyond the Nation's boundaries or return's by streamflow or subsurface flow to the ocean.

Overall, these numbers indicate no shortages of water at the national level. In many areas, however, water is in short supply, is not available when it is needed, or is of poor quality.

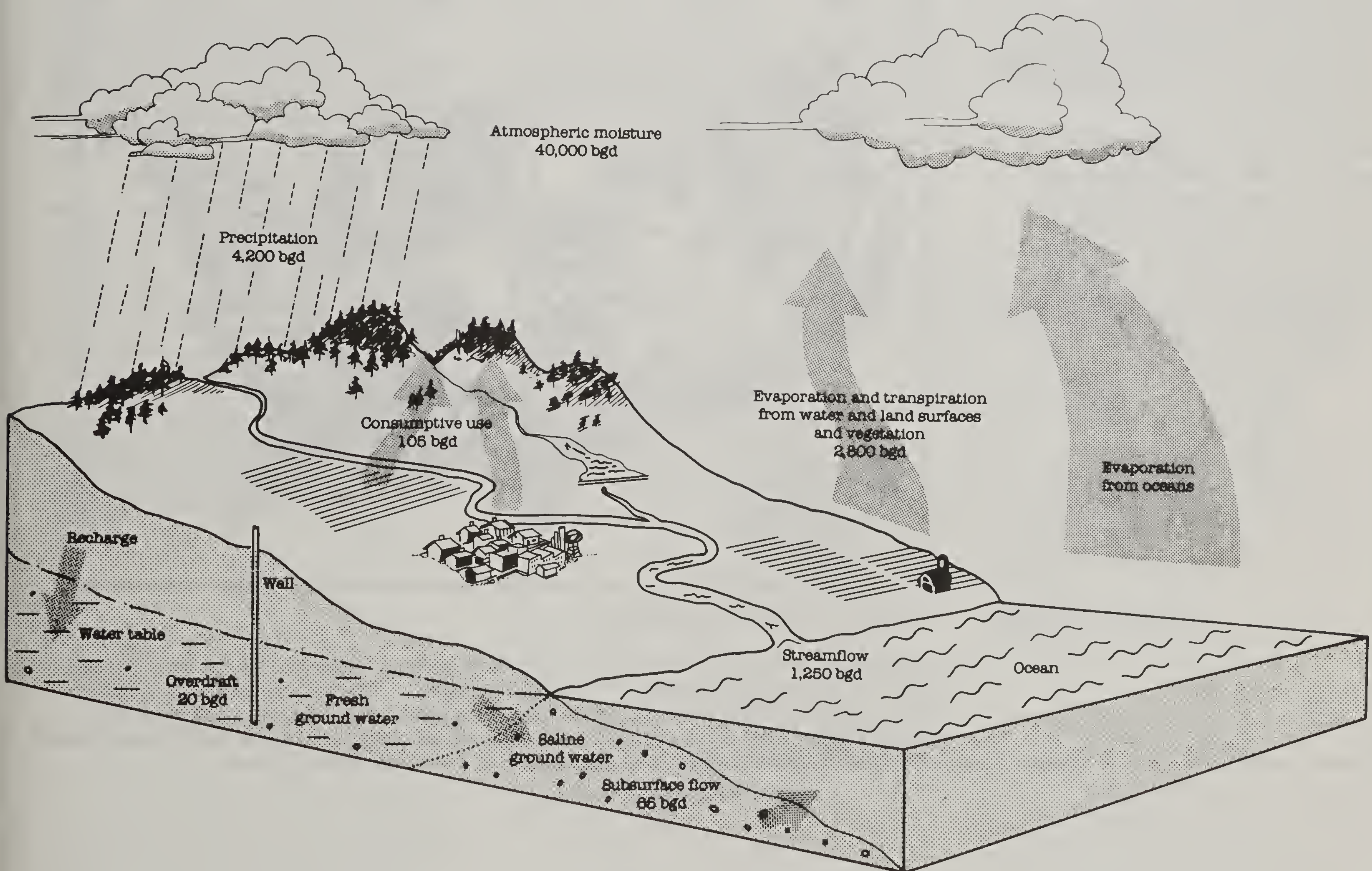


Figure 96.--Hydrologic cycle of the conterminous United States

Water continuously circulates from the oceans to the atmosphere to the land, from where it returns to the atmosphere by evaporation or transpiration or to the oceans by streamflow. Many human activities--especially those of agriculture--affect the distribution of water on land and in the atmosphere by directly consuming or evaporating water, by altering the land and vegetation, or by influencing the climate.

Precipitation is the source of almost all our water. Some localities add to the supplies provided by precipitation by drawing upon water that has accumulated in aquifers over hundreds of years, water transferred from other river basins, and desalted ocean water.

The 30 inches of average annual precipitation falling on the United States actually ranges from less than 4 inches in parts of the Great Basin and Lower Colorado Regions to more than 200 inches in some parts of the coastal area of the Pacific Northwest.

About 1,000 bgd of precipitation run off the land directly into streams, rivers, lakes, and reservoirs. These surface waters evaporate, move into the ground, flow through the drainage system to the sea, or are diverted for offstream uses.

About 400 bgd of precipitation soak into the ground below the root zone and move downward to recharge ground water supplies. Ground water comes to the land surface in springs or seeps, emerges as streamflow, enters the ocean as subsurface flow, or is withdrawn by pumping.

Ground water

Ground water is the water that saturates sediments and permeable rock strata beneath the earth's surface. The amount of fresh ground water is much greater than the amount of fresh water in streams and lakes. The ground water within one-half mile of the earth's surface in the contermi-nous United States amounts to more than 130 billion acre-feet, or enough to fill Lake Michigan 33 times over (fig. 97).

About 44 billion acre-feet of water are of acceptable quality and close enough to the land surface to be tapped with con-ventional wells (appendix table 38). Ground water is available in at least small amounts nearly everywhere, but the quantity wells yield varies greatly. Most ground water development occurs in areas where wells yield more than 50 gallons of fresh water per minute.

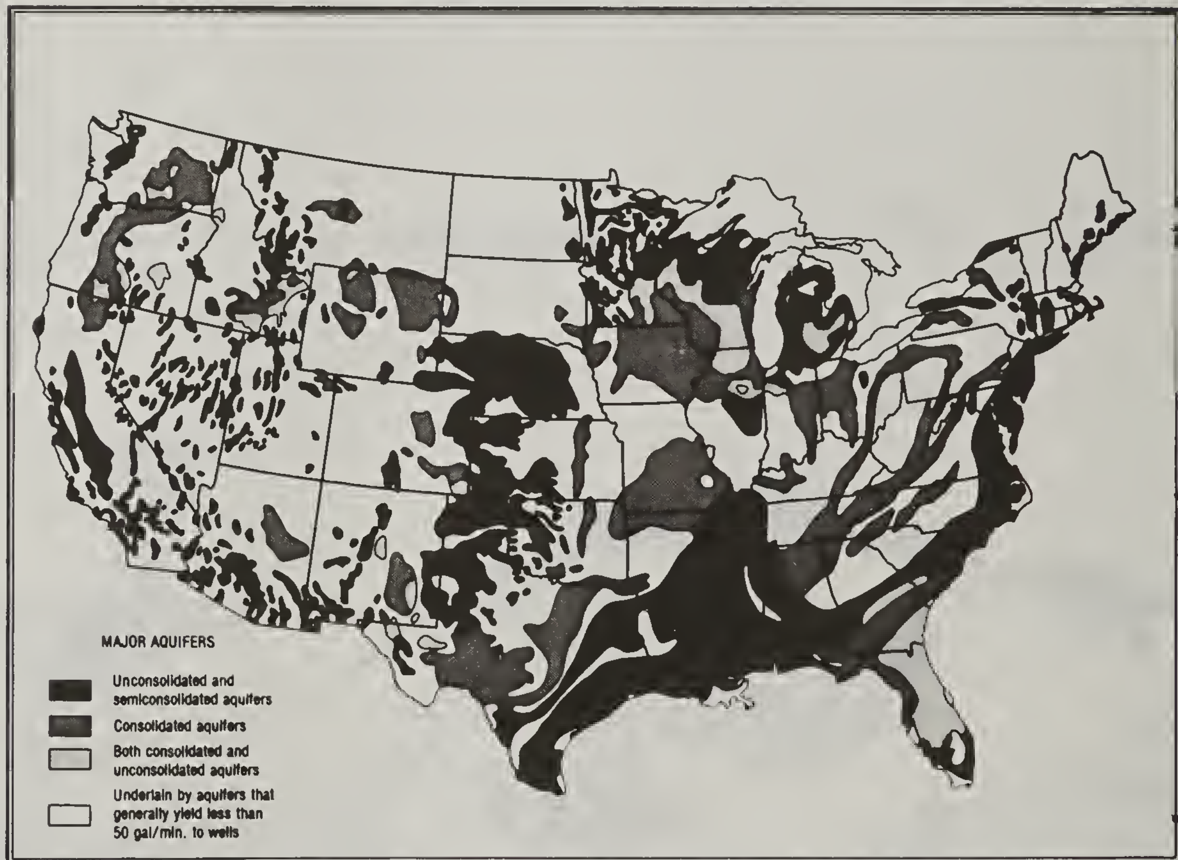


Figure 97.--Major aquifers.

More than 80 percent of all the water pumped from wells in the United States comes from gravel or sand aquifers. If the aquifer is adjacent to a watercourse, infiltration from the river normally replaces the water withdrawn from wells. Consolidated rock aquifers may yield enough water for modest-scale irrigation or for industrial uses.

Surface water

Surface water is water flowing in streams and rivers and stored in lakes, wetlands, and reservoirs. The total area of inland water in the contiguous United States, excluding the Great Lakes, bays, and estuaries, is 48.3 million acres.

In an average year, 1.4 billion acre-feet (1.23 trillion gallons per day) flow through streams and rivers of the contiguous United States into the oceans. These flows comprise runoff from precipitation (fig. 98), discharges from ground water seeps and springs, and return flows from human activity. Without human intervention, outflows would be a direct function of precipitation, the long-term recharge of the ground water system would be balanced by long-term discharge, and overdrafts would not occur. Natural outflows would average 1.6 million acre-feet per year (1.33 trillion gallons per day).

Water supply and use across the Nation can best be described in terms of water resources regions (fig. 99). There are 21 regions, 18 of which are in the conterminous United States. Each water resources region is made up of drainage basins of tributaries or coastal drainage areas of a group of streams called subregions. Each subregion consists of watersheds of a few thousand acres to several hundred thousand acres.

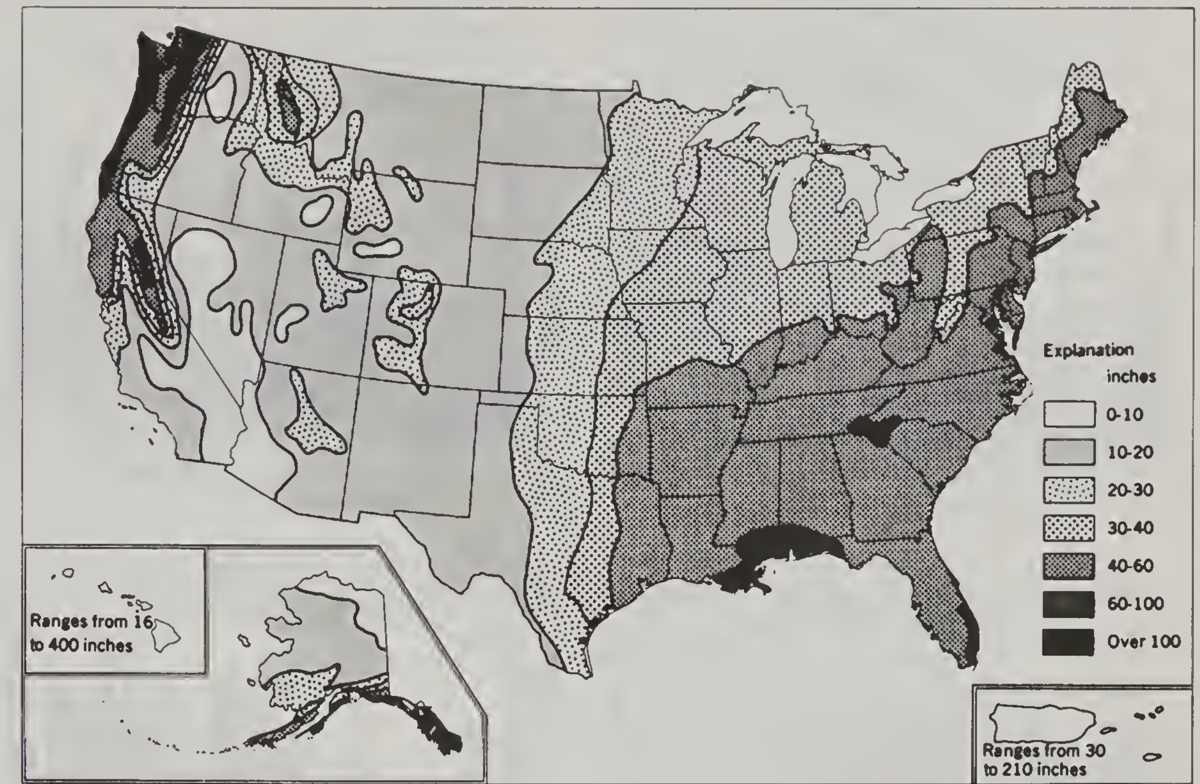


Figure 98.--Average annual precipitation in the United States.

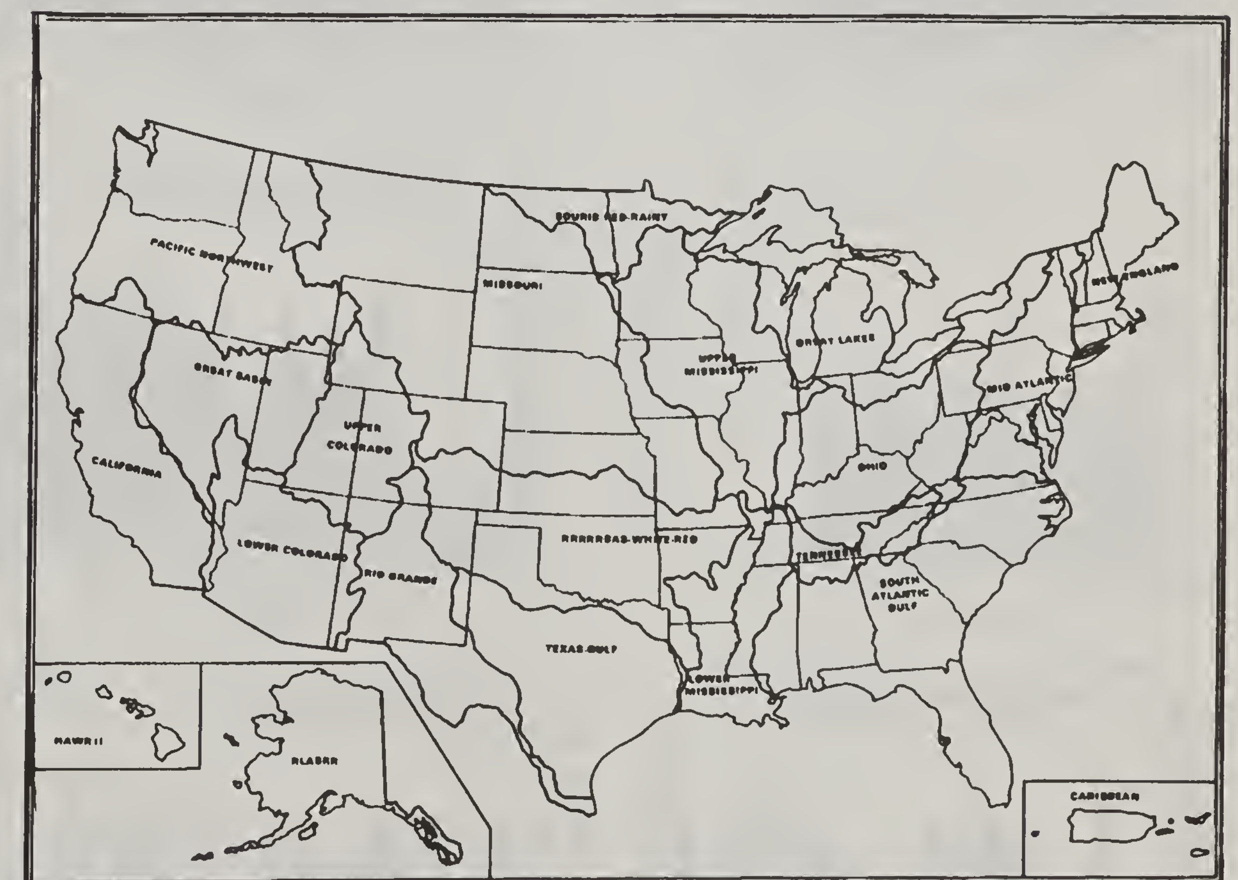
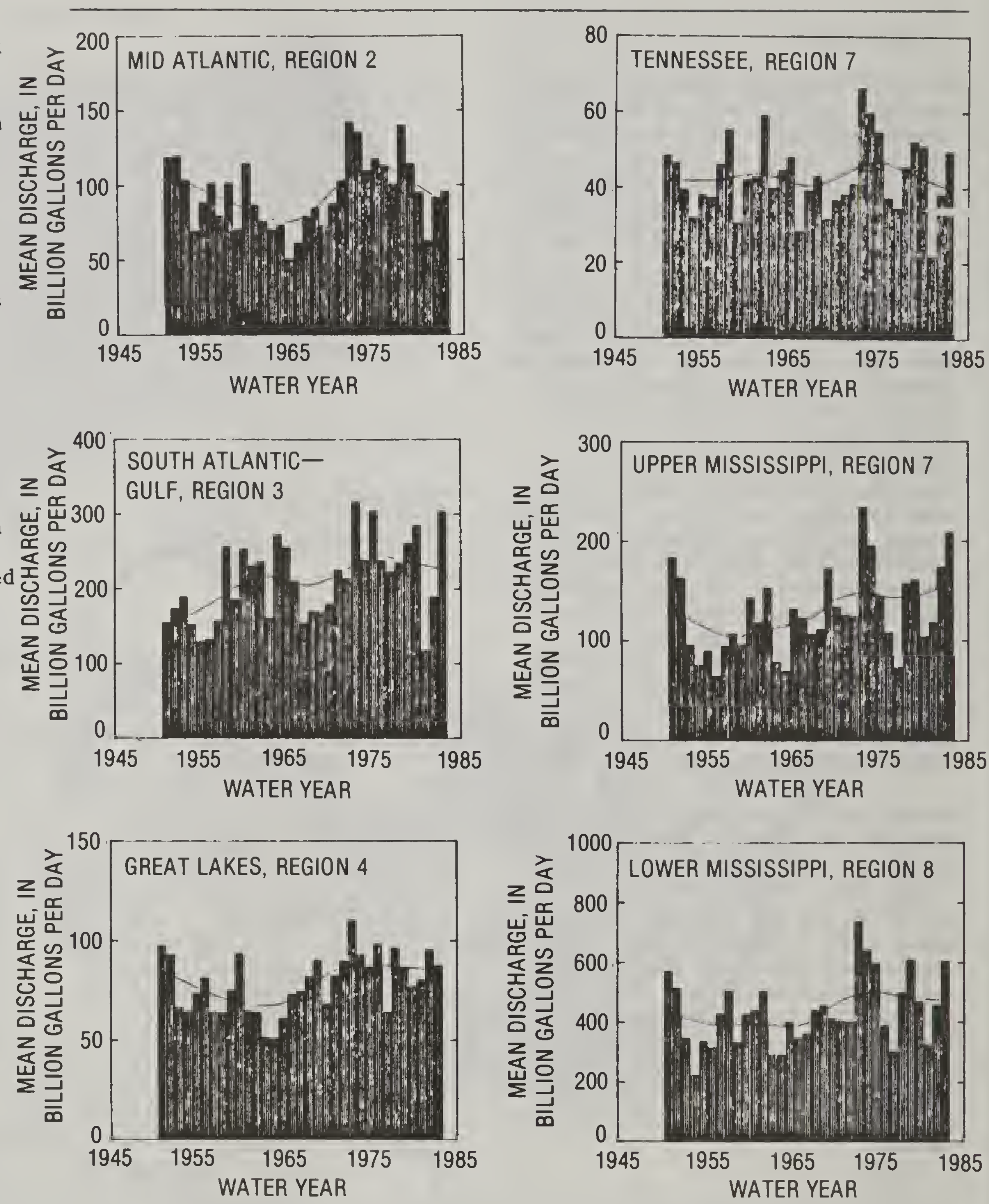


Figure 99.--Water resources regions.

There is great contrast between the quantity of water flowing out of a water resources region during an average year and that in a wet year or a dry year, between average seasonal flows and those of exceptional seasons, and between monthly high and low flows. Both annual and seasonal streamflows vary least in the Northeast. Annual streamflow in the Southwest ranges from less than 30 percent to more than 200 percent of mean annual streamflow. Monthly streamflows are even more erratic.

Weather conditions and, consequently, precipitation, runoff, and streamflows fluctuate widely from year to year (fig. 100). In very dry years, the total yearly flows from the conterminous United States may be less than 770 million acre-feet (675 bgd)--about 55 percent of the average (1,233 bgd). In very wet years, the total yearly flows may exceed 2,180 million acre-feet (1,955 bgd).



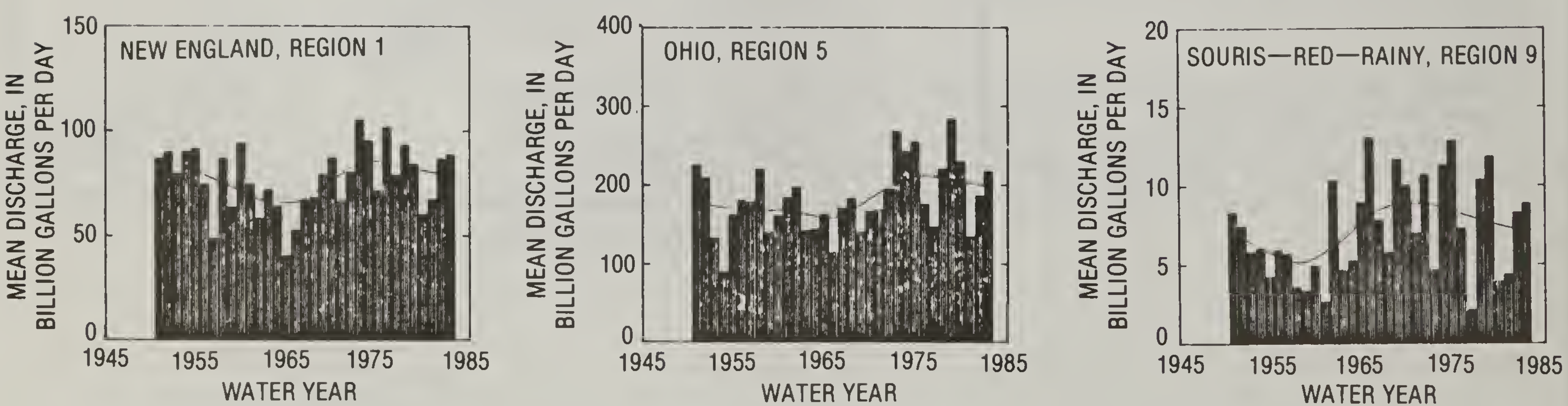
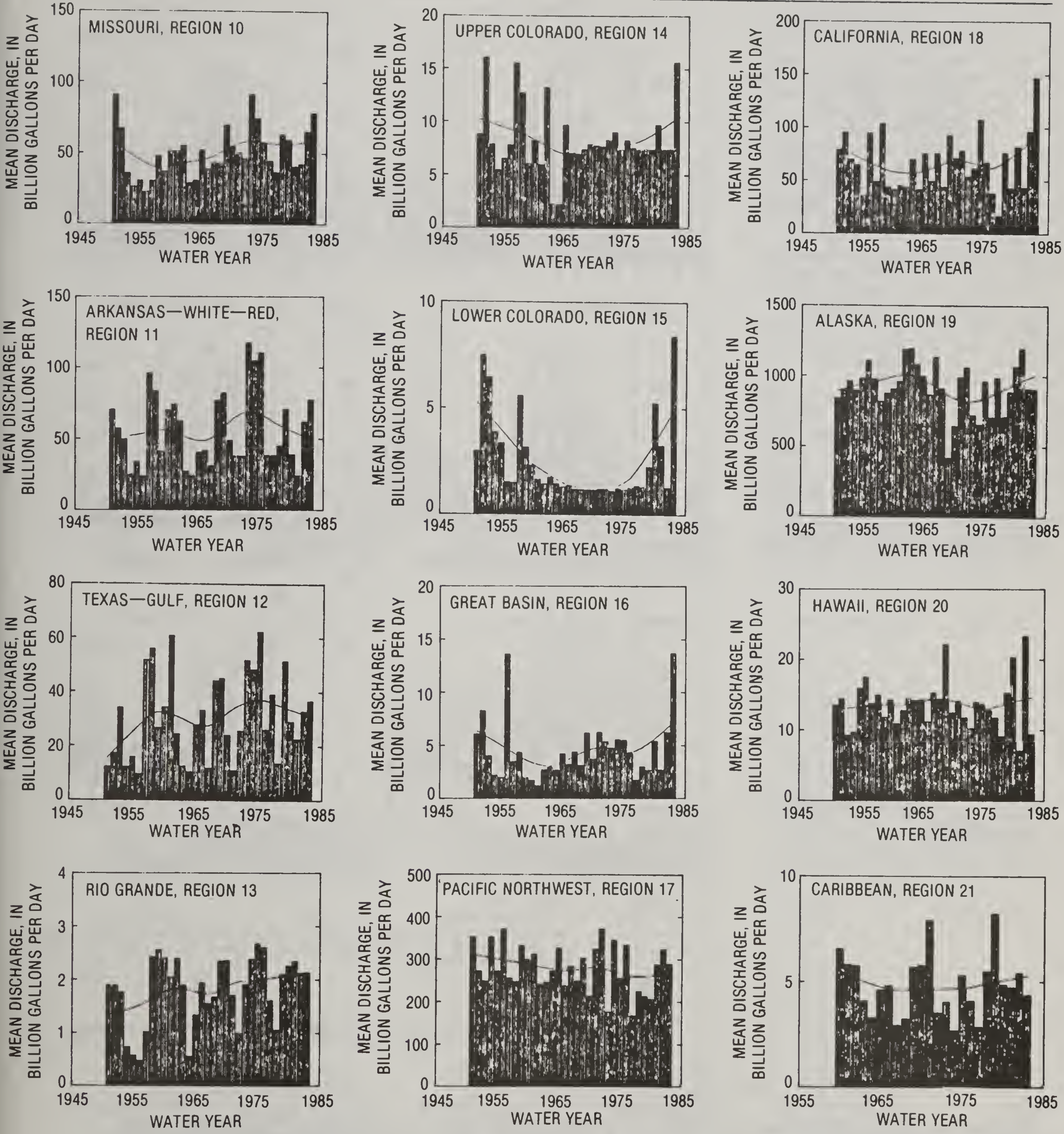


Figure 100.--Yearly streamflows, by water resources region, for water years 1950-1982. Mean discharge in billion gallons per day (USGS Geological Survey).


MISSOURI, REGION 10
UPPER COLORADO, REGION 14
CALIFORNIA, REGION 18
ARKANSAS—WHITE—RED, REGION 11
LOWER COLORADO, REGION 15
ALASKA, REGION 19
TEXAS—GULF, REGION 12
GREAT BASIN, REGION 16
HAWAII, REGION 20
RIO GRANDE, REGION 13
PACIFIC NORTHWEST, REGION 17
CARIBBEAN, REGION 21
MEAN DISCHARGE, IN BILLION GALLONS PER DAY
WATER YEAR

Seasonal flows also vary across the Nation. Seasonal variation is relatively small in the Northeast. In the midcontinent area, summer storms from May to October produce more than twice the precipitation that occurs during the rest of the year. Thunderstorms provide inland areas with precipitation in summer, hurricanes bring rain to coastal areas in fall, and cyclonic storms occur in winter in the Southeast. In western mountain areas, the heaviest precipitation occurs as snow in winter. In the Southwest, up to 75 percent of the annual runoff occurs during a few weeks in spring when snow melts. During summer, much of California has virtually no precipitation. Coastal Alaska receives precipitation mainly late in fall; the interior receives it mainly in summer. In both Hawaii and the Caribbean, fall is the wet season and early spring the dry. Figure 101 shows the normal distribution of monthly flows and the size of high and low monthly flows relative to average monthly flows.

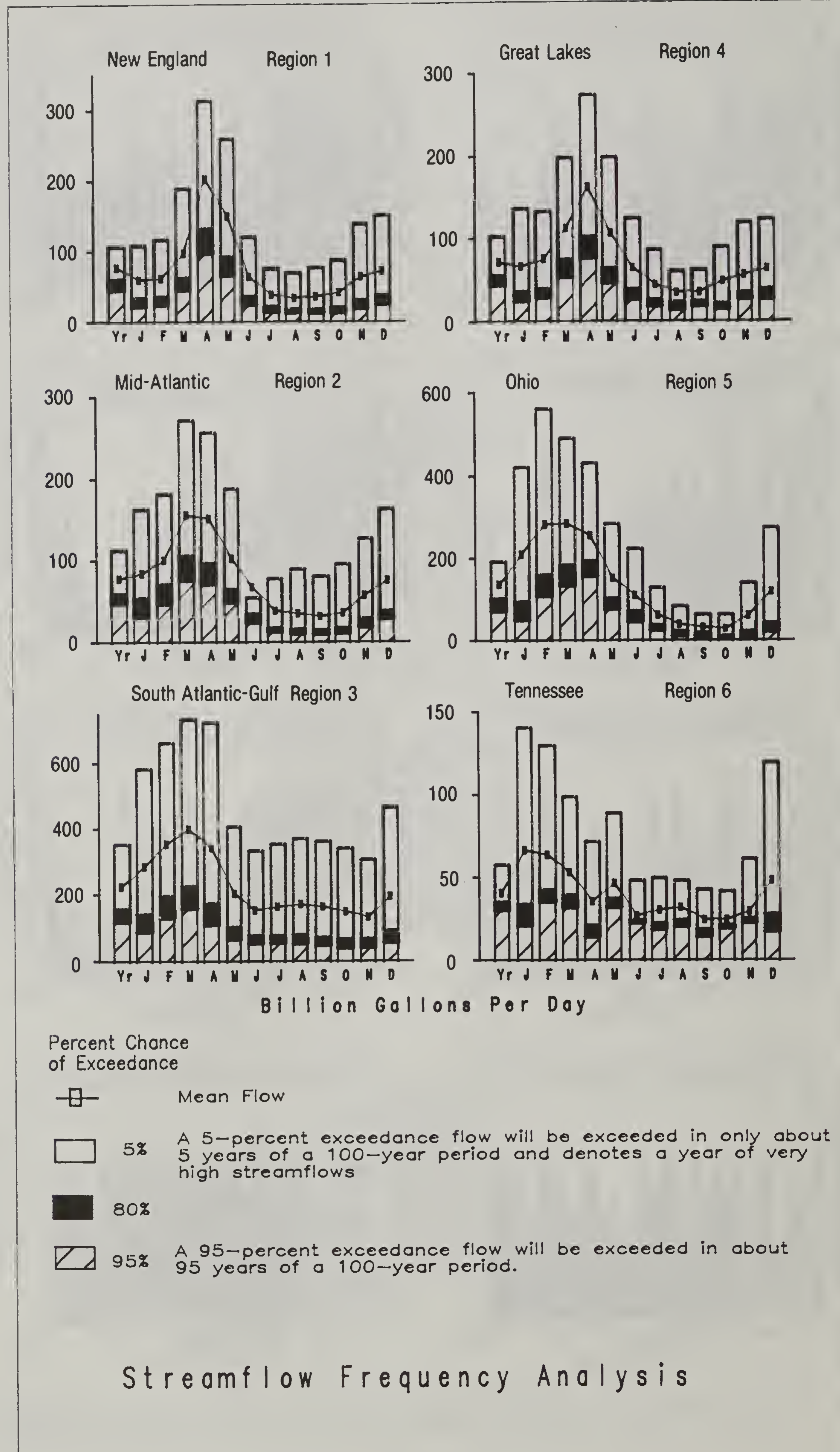
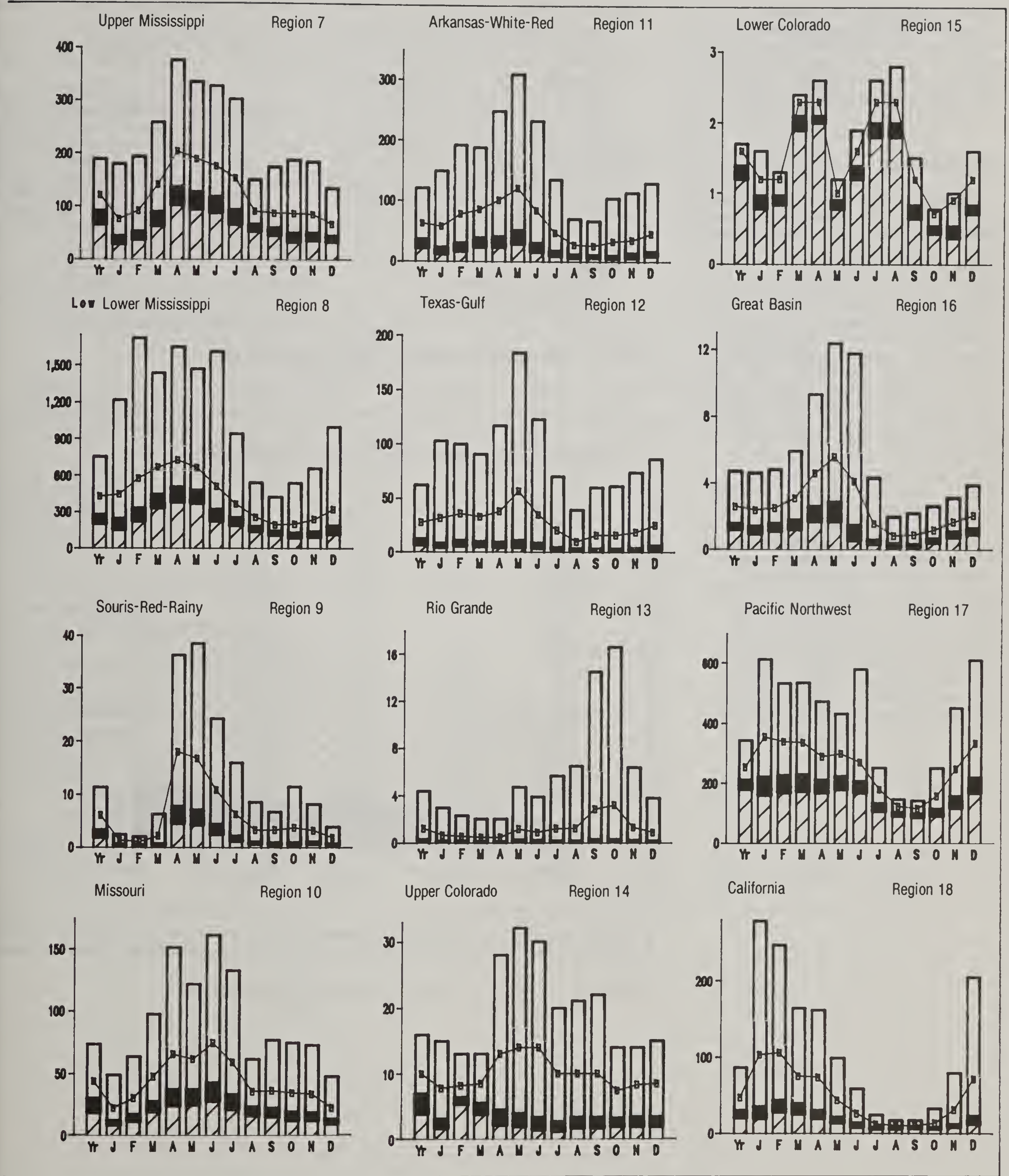


Figure 101.--Regional streamflow frequency analysis. (Second National Water Assessment).



Upper Mississippi
Region 7
Arkansas-White-Red
Region 11
Lower Colorado
Region 15
Low Lower Mississippi
Region 8
Texas-Gulf
Region 12
Great Basin
Region 16
Souris-Red-Rainy
Region 9
Rio Grande
Region 13
Pacific Northwest
Region 17
Missouri
Region 10
Upper Colorado
Region 14
California
Region 18
Yr J F M A M J J A S O N D

Water is used offstream and instream. Offstream water is withdrawn or diverted from a ground or surface source to its place of use. Instream water is used where it naturally flows.

OFFSTREAM USES

An estimated 309 billion gallons per day (bgd) of fresh water are withdrawn from ground and surface water sources (table 63). About 105 bgd are consumptively used--that is, are returned to the atmosphere or incorporated into the plant or animal tissue or commodity produced, or percolate beyond the area of reuse. The rest of the withdrawals (204 bgd) return to the water supply and are available for downstream uses. An additional 72 bgd of saline water are withdrawn from the oceans, primarily for industry. Only 2 bgd are consumptively used; 70 bgd are returned to the oceans and estuaries.

Of the freshwater withdrawals, 213 bgd are from surface water sources and 96 bgd are from ground water sources (fig. 102). Water sources vary by region. Saline water withdrawals are greatest in the Mid-Atlantic Region. Surface water is the dominant source in the north-central regions. California is the big user of ground water.

Table 63.--Offstream water uses for the United States, 1982

Type of use	Withdrawal	Consumption
	(billion gallons per day)	
Domestic	21.1	5.8
Commercial and public use	12.0	3.7
Industrial uses: steam, electric, manufacturing, minerals, etc.	144.1	15.9
Agriculture	131.6	79.9
Irrigation	129.4	78.0
Livestock	2.2	1.9
Subtotal, freshwater	308.8	105.3
Subtotal, saline	72.0	2.2

Source: SCS analysis based on USGS Circular 1001.

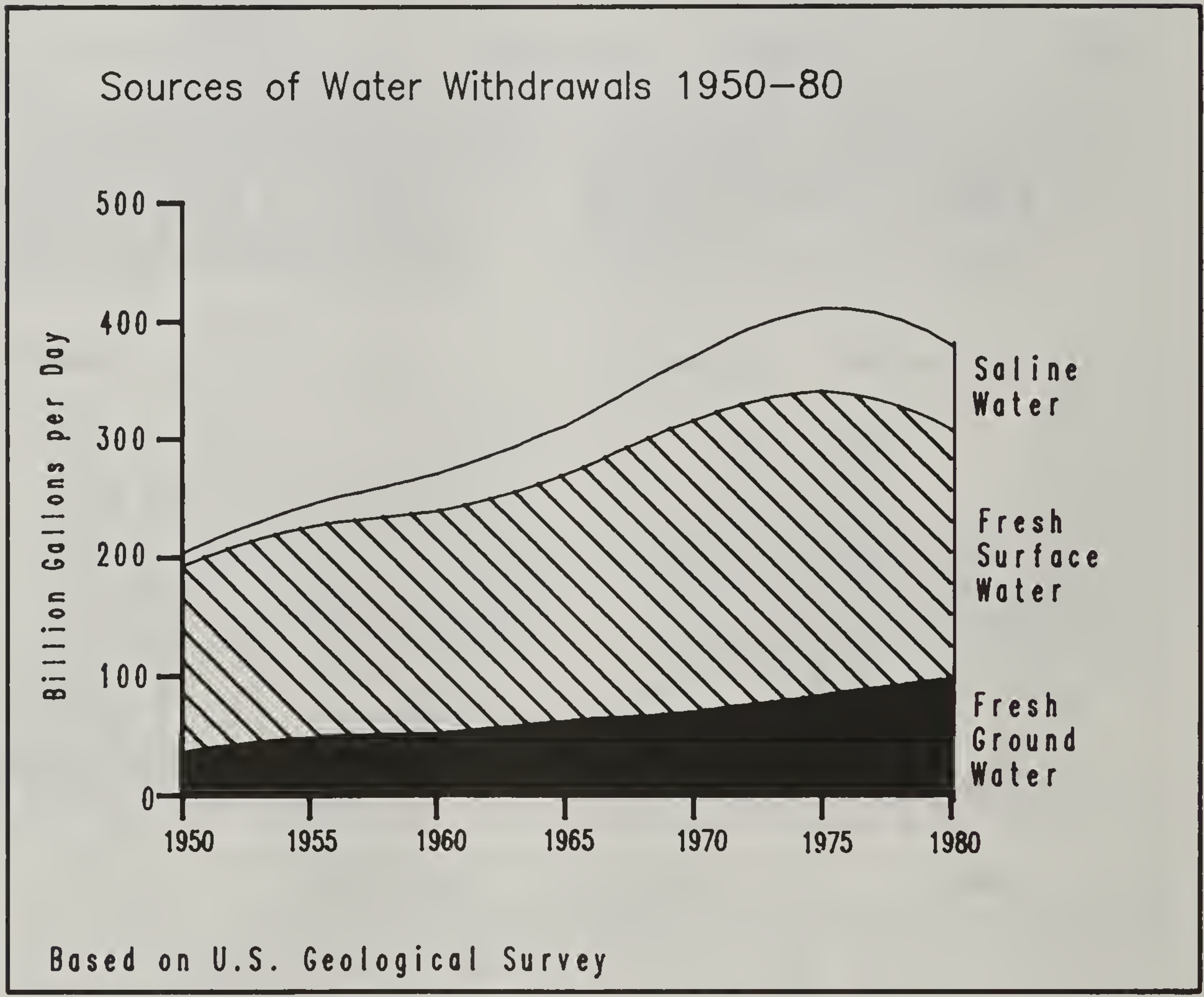


Figure 102.--Sources of water withdrawals, 1950-1980.

Nonagricultural Water Use

Table 64 shows nonagricultural water uses, by region.

Domestic Water Use.--The 91 million households in the United States use an average of 230 gallons of water per household daily. Domestic water use is affected by availability, source, system ownership, quality and reliability of supplies, outdoor uses, and cost.

Domestic per capita water use is smallest in the Northeast and largest in the West. Most of the regional differences are in the amount needed for outdoor uses, such as cleaning windows and vehicles, watering lawns and gardens, and recreational uses. The amount used indoors in about the same from region to region, except for the amount used to cool the house.

About 23 percent of central-system withdrawals and 60 percent of self-supplied withdrawals are consumptively used.

The 83 percent of the U.S. population that receives its domestic water from public systems and private companies accounts for 87 percent of domestic withdrawals and 72 percent of domestic consumption (table 65). Ground water makes up 35 percent of centrally-supplied domestic water withdrawals.

Table 64.--Nonagricultural offstream water use, by region, 1982

	Water resources region	Withdrawal				Consumption			
		Domestic	Commercial, public, & public land	Industrial	Total	Domestic	Commercial, public, & public land	Industrial	Total
		(million gallons per day)							
1	New England	996	535	2,912	4,443	272	112	213	597
2	Mid-Atlantic	3,052	1,519	11,580	16,151	826	347	961	2,134
3	South Atlantic-Gulf	2,613	1,157	19,652	23,422	801	267	2,354	3,422
4	Great Lakes	2,379	1,171	29,859	33,409	666	273	2,107	3,046
5	Ohio	1,710	814	26,561	29,085	514	183	1,650	2,347
6	Tennessee	336	160	7,804	8,300	105	35	461	601
7	Upper Mississippi	1,189	562	10,249	12,000	341	130	620	1,091
8	Lower Mississippi	638	302	13,760	14,700	182	72	1,043	1,297
9	Souris-Red-Rainy	62	30	71	163	20	8	27	55
10	Missouri	937	653	6,738	8,328	256	292	533	1,081
11	Arkansas-White-Red	719	421	2,412	3,552	201	112	750	1,063
12	Texas-Gulf	1,128	587	2,480	4,195	291	134	2,008	2,433
13	Rio Grande	249	161	279	689	65	55	241	361
14	Upper Colorado	66	179	742	987	18	127	185	330
15	Lower Colorado	389	276	680	1,345	95	94	550	739
16	Great Basin	209	463	742	,1414	52	376	221	649
17	Pacific Northwest	920	1,000	4,079	5,999	259	361	542	1,162
18	California	2,817	1,920	3,040	7,777	679	716	1,288	2,680
	Contiguous states	20,408	11,908	143,640	175,959	5,641	3,693	15,753	25,088
19	Alaska	105	56	170	294	8	13	43*	63
20	Hawaii	172	93	130	338	52	28	88	152
21	US Caribbean	376	184	185	613	61	30	5	77
	Nation	21,061	12,241	144,125	177,204	5,762	3,764	15,890	25,380

Source: SCS analysis based on USGS Circular 1001.

About 17 percent of the population obtains its water from individual wells, springs, ponds, or catchments. Ground water makes up 97 percent of the 2.7 billion gallons of water per day of self-supplied domestic water withdrawals.

More and more people are hooking into central systems (table 66). Domestic water withdrawals are projected to increase to 32 bgd and consumption to 8 bgd by 2030.

Commercial and Public Uses.--Commercial establishments and public water uses (which include control system delivery losses and water for municipal parklands and swimming pools, street cleaning, and fire-fighting) are in areas served by central systems. An estimated 9.8 bgd are withdrawn and 2.2 bgd are consumed by these establishments and uses.

Public lands are maintained to preserve natural and historic resources and to provide outdoor recreation. About two-thirds of the 2.2 bgd withdrawn for public land are consumptively used. Water for the land and facilities at the site generally is self-supplied.

Industrial Water Use.--Two-thirds of industrial withdrawals are for producing energy--mostly for steam electric power generation. Thermoelectric plants use different techniques to dispose of cooling water. Many plants return the warmed water directly to receiving waters; others use cooling towers and ponds to reduce withdrawals and thermal pollution. As a result of advanced cooling technologies, withdrawals are expected to increase at a much slower rate than consumption.

Manufacturing and mining industries withdraw an estimated 47 bgd and consumptively use 11.8 bgd. Water uses by steel, chemical, paper, mining, petroleum refining, and other industries vary widely. Manufacturers and miners are expected to continue to increase recycling or improve treating used water. Therefore, withdrawals per unit of production value are expected to decline further and consumption per unit of production value to remain about the same.

Agricultural Water Use

Table 67 summarizes agricultural water use. See also chapter 6.

Livestock.--Of the 2,164 million gallons of water per day (mgd) used for production of red meat, poultry and eggs, and milk, 1,200 mgd are from ground water and 964 mgd from surface water. Most of the withdrawals are consumptively used--perhaps 10 to 15 percent of the livestock water withdrawals return to water supplies.

In 1983, an average of 1,600 mgd were used to produce 17.8 million tons (carcass weight) of beef, mutton, and pork; 460 mgd to produce 1,400 million hundredweight of milk; and 104 mgd to produce 5,676 million dozen of eggs and 15,750 million pounds of live-weight poultry. Water withdrawals for horses, domesticated reindeer, goats, rabbits, household pets, and animals raised for fur or for scientific purposes, aquaculture, and fish and wildlife are not included.

Drinking water accounts for 60 percent of the livestock water use. The amount of drinking water used by livestock depends on the animal and its environment, including the species, size, age, sex, and production of the animal; amount and content of the feed; the animal's access to water; and the air temperature. Other livestock water uses include dairy sanitation, cleaning and waste disposal, cooling, on-farm processing, and water losses including evaporation from stockwater ponds.

Irrigation.--About 40 percent of all freshwater withdrawals are for agricultural irrigation. Irrigators in the United States pump an average 66.9 million gallons of ground water per day and divert 62.2 million gallons

Table 65.--U.S. urban and rural populations, by type of water-supply system, 1980

	Urban	Rural	Total
		(1,000)	
Population	167,051	59,495	226,546
Central systems	158,033	31,359	189,392
Self-supplied systems--	9,018	28,136	37,154
With pressure (bathroom)	5,979	24,626	30,605
With limited or no pressure--	3,039	3,510	6,549
Incomplete plumbing facilities	3,039	2,056	5,095
No plumbing facilities	0	1,454	1,454

Source: 1980 Census of Housing.

Table 66.--Population served by central and self-supplied systems, by selected years

	1969	1975	1980	1985
		(million people)		
Population	204	216	226	236
Central	166	179	189	202
Self-supplied--	38	37	37	34
With pressure	30	31	31	
Lacks full pressure	8	6	6	

of surface water per day. Crops evapotranspire 61 million gallons per day.

Vegetative water use is affected by both natural and management factors. Important natural factors include precipitation, humidity, temperature, solar radiation, wind movement, and length of growing season. Irrigation water use is described in chapter 6 of this report.

Some additional land could be irrigated in the future, should the need arise. There are an estimated 56 million acres of potentially irrigable land, that is, potential cropland or nonirrigated cropland in proximity to water supplies. An estimated 23 million acres are in the West and 33 million acres in the East. Figure 103 shows the acreage of potentially irrigable land in each water resources region.

INSTREAM USES

Instream uses generally do not reduce supplies. Lakes, reservoirs, wetlands, streams, and rivers provide habitat for fish and wildlife, flows for recreation and waste assimilation, waterways for navigation, supplies for hydroelectric power generation and treaty and compact obligations, and surfaces for esthetic purposes. Waters can serve several instream uses simultaneously.

Recreation

Water-related outdoor recreation can be divided into two types: water-dependent activities, which require a substantial supply of accessible water, and water-enhanced, where the presence of water is desirable but not necessary. Only about one-fifth of the 108 million acres of surface water is accessible and usable for recreation. The other 87 million acres are inaccessible, polluted, or otherwise restricted from recreational use.

Fish and Wildlife

Many fish and wildlife species are sensitive to change in their riverine, wetland, or coastal environments. A riverine ecosystem is a watercourse containing flowing water at least part of the year and supporting a biotic community of aquatic plants and animals. Beyond the stream channel, the ecosystem generally includes a zone of riparian vegetation dependent upon surface or subsurface flow and a flood plain that is formed by the kinetic energy of the stream during periods of high flow.

Table 67.--Livestock and irrigation water use in 1982, by water resources region

	Region	Livestock		Irrigation		Total Agriculture	
		Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
		(million gallons per day)					
1	New England	18	16	27	19	45	35
2	Mid-Atlantic	69	62	238	164	307	226
3	South Atlantic-Gulf	166	150	3,543	2,439	3,709	2,589
4	Great Lakes	85	76	471	326	556	402
5	Ohio	127	114	96	67	223	181
6	Tennessee	31	28	18	12	49	40
7	Upper Mississippi	283	254	536	394	819	648
8	Lower Mississippi	54	49	5,692	3,916	5,746	3,965
9	Souris-Red-Rainy	33	29	159	101	192	130
10	Missouri	502	452	24,425	14,884	24,927	15,336
11	Arkansas-White-Red	237	214	8,474	5,892	8,711	6,106
12	Texas-Gulf	191	172	8,825	6,110	9,016	6,282
13	Rio Grande	38	34	3,931	2,627	3,969	2,573
14	Upper Colorado	29	26	4,601	2,404	4,630	2,430
15	Lower Colorado	53	47	4,782	2,997	4,835	3,044
16	Great Basin	33	30	5,722	3,066	5,755	3,096
17	Pacific Northwest	88	79	25,711	12,323	25,799	12,402
18	California	117	105	30,912	19,585	31,029	19,690
	Contiguous U.S.	2,153	1,938	128,163	77,327	130,316	79,265
19	Alaska	1	1	1	1	1	1
20	Hawaii	3	2	837	480	840	482
21	U.S. Caribbean	8	7	417	233	425	240
	National total	2,164	1,947	129,417	78,040	131,581	79,987

Source: SCS

There are about 666 thousand miles of perennial streams, 116.9 million acres of open flood plain (land in pasture, range, or forest), and 48.4 million acres of surface water that provide riparian and aquatic habitats.

Instream flow requirements for fish and wildlife are those amounts of water flowing through a stream channel that support aquatic life at an acceptable level. Habitat conditions may be categorized as optimum, good survival for most aquatic life forms, and short-term survival habitat. Generally, optimum habitat requires more than 75 percent of the total streamflow in humid areas and 50 percent in subhumid and semi-arid areas. Good survival habitat requires more than 60 percent of the total streamflow in humid areas and 30 percent in subhumid and semi-arid areas.

Hydropower

Hydroelectric power plants produce power without consuming fuel and without polluting water and air. They capture energy by releasing water. Hydroelectric generation supplied 321 billion kilowatt hours in 1984--about 13.3 percent of the electric power generated and 5 percent of the Nation's total energy production. Hydroelectricity provides base loads in the Pacific Northwest, where much of the hydropower generation occurs. It generally provides only peak loads in the rest of the Nation.

Because of low operating costs and advances in low-head flow generation and rewinding generators, interest has renewed in the potential for hydroelectric power generation.

Navigation

Carriers moved 357 billion ton-miles on inland navigable waterways in 1983. More than 25,000 miles of navigable waterways are used to transport commodities. Domestic waterborne traffic increased from 829 million tons in 1965 to 1 billion tons in 1974, peaked in 1979, and dropped back to 1 billion tons in 1983. Domestic waterborne commerce accounted for 16 percent of the net tonnage carried commercially. The instream flow required for navigation depends on the size and depth of the channel and the number and operation of the locks. Even though 50 percent more waterborne freight is expected by the turn of the century, water supplies for navigation should be adequate.

Preservation

In certain natural or historical areas, surface flows, ground water levels, and high water quality must be maintained. In some locations, minimum water flow is needed to meet commitments in treaties and compacts, to meet local or state health standards, and to support established esthetic values.

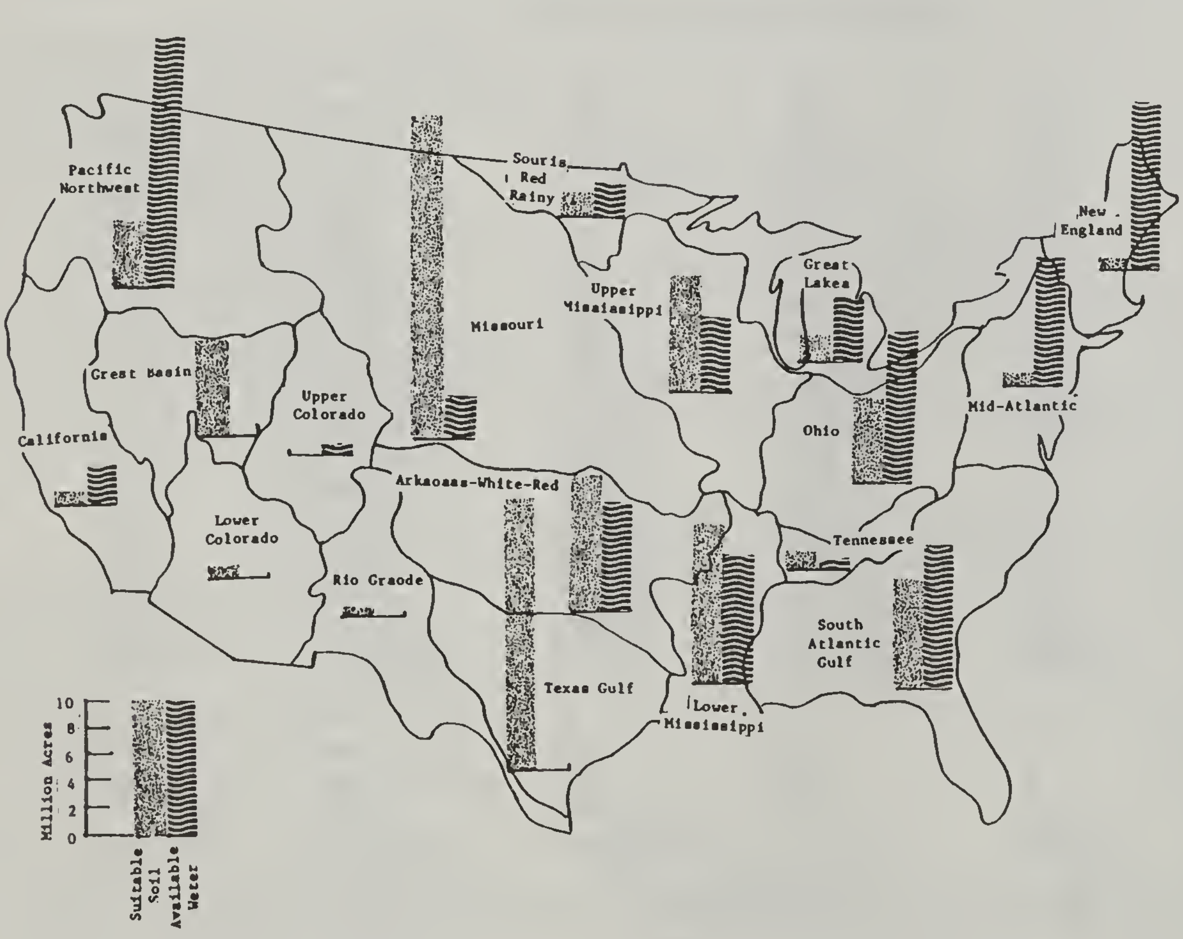


Figure 103.--Potentially irrigable land.

APPENDIX C:
Tables

Land use definitions used in these tables are as follows:

CROPLAND--Land used for the production of adapted crops for harvest, alone or in rotation with grasses and legumes. Adapted crops include row crops, small grain, hay, nursery crops, orchard and vineyard crops, and other similar specialty crops.

PASTURELAND--Land used primarily for the production of adapted, introduced, or native species in a pure stand, grass mixture, or a grass-legume mixture. Cultural treatment in the form of fertilization, weed control, reseeding, or renovation is usually a part of pasture management in addition to grazing management.

RANGELAND--Land on which the climax vegetation (potential natural plant community) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing and browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundra, and certain forb and shrub communities. It also includes areas seeded to native or adapted introduced species that are managed like native vegetation. Federal rangeland includes 40,663 million acres administered by the USDA Forest Service, 201,294 million acres administered by the Bureau of Land Management, and 86,930 million acres administered by other federal agencies.

FOREST LAND--Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use. The minimum area for classification of forest land is 1 acre and must be at least 100 feet wide. Forest land is distinguished from rangeland in transition vegetation types if the tree canopy cover exceeds 10 percent. Forest lands include cutover areas temporarily unstocked as well as young stands and plantations established for forestry purposes which do not yet have 10 percent crown cover.

OTHER LAND--A category of land cover and land use that includes farmsteads, other land in farms, stripmines, quarries, gravel pits, borrow pits, permanent snow and ice, small built-up areas, and all other land that does not fit into any other land cover or land use category.

Appendix table 1.--Land cover/use of nonfederal rural land in 1982, by land capability class and subclass

Class and subclass	Cropland	Pastureland	Range-land	Forest land	Minor land cover/use	Total
			(1,000 acres)			
I	30,219.1	2,562.4	514.9	1,930.4	803.2	36,030.0
IIe	91,363.1	18,924.6	9,748.3	23,836.2	3,951.0	147,823.2
IIw	64,951.8	10,816.9	2,536.2	16,122.7	1,879.8	96,307.4
IIs	17,187.0	1,996.8	1,313.3	3,043.0	462.9	24,003.0
IIc	17,758.5	762.5	3,149.5	611.1	395.0	22,676.6
Subtotal	191,260.4	32,500.8	16,747.3	43,613.0	6,688.7	290,810.2
IIIe	82,720.3	27,237.0	37,886.7	32,152.9	3,165.3	183,162.2
IIIw	33,291.7	8,388.1	3,975.1	20,734.9	2,872.9	69,262.7
IIIs	12,498.1	4,397.1	2,348.8	8,457.4	670.7	28,372.1
IIIc	5,164.6	201.8	2,178.1	45.8	119.2	7,709.5
Subtotal	133,674.7	40,224.0	46,388.7	61,391.0	6,828.1	288,506.5
IVe	32,479.2	16,648.3	42,815.4	30,574.2	1,641.0	124,158.1
IVw	7,191.3	4,908.3	4,312.1	15,720.7	1,138.5	33,270.9
IVs	6,821.9	3,951.8	4,509.6	11,296.5	650.9	27,230.7
IVc	470.4	79.4	1,448.0	50.2	18.1	2,066.1
Subtotal	46,962.8	25,587.8	53,085.1	57,641.6	3,448.5	186,725.8
V	2,356.7	4,456.6	5,896.6	18,971.8	1,976.2	33,657.9
VIe	9,928.6	12,466.4	96,356.9	48,429.3	1,314.4	168,495.6
VIw	1,181.0	1,628.5	4,461.0	9,247.8	3,757.8	20,276.1
VIs	2,801.3	3,967.1	32,000.2	29,693.2	811.3	69,273.1
VIc	193.7	49.5	6,293.6	435.3	79.9	7,052.0
Subtotal	14,104.6	18,111.5	139,111.7	87,805.6	5,963.4	265,096.8
VIIe	1,303.6	4,644.6	53,948.8	55,033.8	1,850.6	116,781.4
VIIw	298.6	467.9	2,441.3	8,195.9	3,096.6	14,500.3
VIIs	1,123.2	4,497.3	79,400.3	55,916.6	3,259.7	144,197.1
VIIc	64.3	29.4	5,034.1	25.3	147.4	5,300.5
Subtotal	2,789.7	9,639.2	140,824.5	119,171.6	8,354.3	280,779.3
VIII	34.5	228.3	3,344.9	3,188.4	20,351.4	27,147.5
NA	0.0	0.0	0.0	0.0	5,222.7	5,222.7
Total	421,402.5	133,310.6	405,913.7	393,713.4	59,636.5	1,413,976.7 1/

1/ To this total may be added the following acreages of lands that are not assigned to a capability classification:

	(1,000 acres)
Urban (small communities) and other built-up land	46,627.7
Rural transportation	26,933.2
Small water areas	10,118.0
Total from table	1,413,976.7
Grand total	1,497,655.6

Source: 1982 National Resources Inventory.

Appendix table 2.--Land cover/use of federal and nonfederal land, by farming region

Farming region and state	Nonfederal land: Cropland	Nonfederal land: Pastureland	Nonfederal land: Rangeland	Nonfederal land: Forest land	Nonfederal land: Other land	Nonfederal land: Total	Federal land	Census water	Grand total
	(1,000 acres)								
NORTHEAST									
Connecticut	244.7	114.0	0	1,828.3	921.5	3,108.5	9.1	94.1	3,211.7
Delaware	519.1	35.2	0	347.6	301.6	1,203.5	33.3	71.7	1,308.5
Maine	953.4	569.0	0	16,770.3	1,409.0	19,701.7	135.0	1,452.9	21,289.6
Maryland	1,794.4	534.1	0	2,425.3	1,360.1	6,113.9	157.9	422.7	6,694.5
Massachusetts	297.2	201.6	0	2,970.1	1,454.2	4,923.1	89.0	289.8	5,301.9
New Hampshire	157.8	124.5	0	4,085.1	665.8	5,033.2	727.1	178.0	5,938.3
New Jersey	809.4	239.6	0	1,848.4	1,737.5	4,634.9	144.5	204.5	4,983.9
New York	5,912.1	3,871.8	0	16,516.9	3,782.9	30,083.7	237.1	1,108.3	31,429.1
Pennsylvania	5,896.3	2,592.6	0	15,300.3	4,270.5	28,059.7	668.0	269.5	28,997.2
Rhode Island	27.2	35.9	0	405.5	202.9	671.5	3.8	100.6	775.9
Vermont	648.4	500.7	0	4,086.5	383.6	5,619.2	315.4	218.3	6,152.9
Region	17,260.0	8,819.0	0	66,584.3	16,489.6	109,152.9	2,520.2	4,410.4	116,083.5
APPALACHIA									
Kentucky	5,934.2	5,879.8	0	10,158.2	2,305.8	24,278.0	1,124.8	459.2	25,862.0
North Carolina	6,694.8	1,980.2	0	16,728.5	3,707.1	29,110.6	2,115.9	2,481.7	33,708.2
Tennessee	5,592.1	5,355.6	0	11,529.1	2,503.1	24,979.9	1,343.1	648.9	26,971.9
Virginia	3,396.9	3,392.0	0	13,625.3	2,648.4	23,062.6	2,347.4	680.6	26,090.6
West Virginia	1,093.1	1,869.1	0	10,422.5	945.2	14,329.9	1,104.0	74.2	15,508.1
Region	22,711.1	18,476.7	0	62,463.6	12,109.6	115,761.0	8,035.2	4,344.6	128,140.8
SOUTHEAST									
Alabama	4,510.3	3,816.6	0	20,633.3	2,593.2	31,553.4	904.4	633.3	33,091.1
Florida	3,556.8	4,273.2	3,803.9	12,430.1	7,464.2	31,528.2	3,129.2	2,887.3	37,544.7
Georgia	6,568.4	2,976.6	0	21,883.6	3,649.5	35,078.1	2,067.9	556.1	37,702.1
South Carolina	3,578.7	1,208.0	0	11,025.5	2,361.0	18,173.2	1,149.8	589.1	19,912.1
Region	18,214.2	12,274.4	3,803.9	65,972.5	16,067.9	116,332.9	7,251.3	4,665.8	128,250.0
LAKE STATES									
Michigan	9,443.1	2,911.0	0	15,359.7	5,654.4	33,368.2	3,087.1	1,002.1	37,457.4
Minnesota	23,024.1	3,589.8	198.5	13,956.3	6,688.6	47,457.3	3,372.6	3,187.3	54,017.2
Wisconsin	11,456.8	3,394.2	0	13,392.8	4,820.2	33,064.0	1,799.9	1,074.0	35,937.9
Region	43,924.0	9,895.0	198.5	42,708.8	17,163.2	113,889.5	8,259.6	5,263.4	127,412.5
CORN BELT									
Illinois	24,727.4	3,157.3	0	3,429.4	3,823.1	35,137.2	492.8	430.8	36,060.8
Indiana	13,781.3	2,211.9	0	3,639.9	2,880.4	22,513.5	488.6	156.5	23,158.6
Iowa	26,440.7	4,536.1	0	1,756.2	2,910.6	35,643.6	171.6	201.0	36,016.2
Missouri	14,998.4	12,573.0	167.8	10,985.6	3,258.5	41,983.3	2,093.6	529.3	44,606.2
Ohio	12,447.1	2,713.9	0	6,380.2	4,350.8	25,892.0	346.1	212.8	26,450.9
Region	92,394.9	25,192.2	167.8	26,191.3	17,223.4	161,169.6	3,592.7	1,530.4	166,292.7

Appendix table 2.--Land cover/use of federal and nonfederal land, by farming region--continued

Farming region and state	Nonfederal land						Federal land	Census water	Grand total
	Cropland	Pastureland	Rangeland	Forest land	Other land	Total			
	(1,000 acres)								
DELTA STATES									
Arkansas	8,101.5	5,793.8	164.6	14,339.8	1,820.8	30,220.5	3,113.7	705.4	34,039.6
Louisiana	6,408.9	2,368.5	241.3	12,895.0	5,188.8	27,102.5	1,104.3	2,354.2	30,561.0
Mississippi	7,415.3	3,975.2	0	15,242.7	1,924.3	28,557.5	1,618.3	345.4	30,521.2
Region	21,925.7	12,137.5	405.9	42,477.5	8,933.9	85,880.5	5,836.3	3,405.0	95,121.8
NORTHERN PLAINS									
Kansas	29,118.3	2,240.9	16,908.9	626.2	2,890.4	51,784.7	584.5	288.3	52,657.5
Nebraska	20,276.7	2,125.3	23,095.7	732.1	2,219.6	48,449.4	638.6	419.3	49,507.3
North Dakota	27,039.2	1,271.9	10,948.4	438.2	2,736.0	42,433.7	1,879.0	936.8	45,249.5
South Dakota	16,947.2	2,703.0	22,783.6	561.6	2,766.4	45,761.8	2,824.4	767.8	49,354.0
Region	93,381.4	8,341.1	73,736.6	2,358.1	10,612.4	188,429.6	5,926.5	2,412.2	196,768.3
SOUTHERN PLAINS									
Oklahoma	11,568.1	7,137.9	15,059.6	6,538.7	2,478.4	42,782.7	1,191.6	797.4	44,771.7
Texas	33,319.6	17,042.8	95,353.1	9,323.6	9,726.2	164,765.3	2,998.3	2,992.7	170,756.3
Region	44,887.7	24,180.7	110,412.7	15,862.3	12,204.6	207,548.0	4,189.9	3,790.1	215,528.0
MOUNTAIN									
Arizona	1,206.3	79.3	30,948.2	4,760.2	3,609.4	40,603.4	32,056.3	300.3	72,960.0
Colorado	10,602.7	1,259.7	24,222.5	4,030.1	2,581.3	42,696.3	23,611.2	310.7	66,618.2
Idaho	6,390.1	1,274.2	6,732.9	3,977.1	1,075.1	19,449.4	33,445.0	586.8	53,481.2
Montana	17,196.9	3,036.0	37,837.0	5,228.0	2,649.2	65,947.1	27,106.9	1,055.2	94,109.2
Nevada	859.7	304.4	7,907.8	356.6	730.0	10,158.5	60,188.7	411.7	70,758.9
New Mexico	2,412.7	163.3	40,981.9	4,733.9	2,955.2	51,247.0	26,419.8	152.4	77,819.2
Utah	2,038.7	490.3	8,489.3	3,234.6	2,450.2	16,703.1	35,818.5	1,813.9	54,335.5
Wyoming	2,587.4	754.8	26,915.1	987.1	1,558.1	32,802.5	29,315.0	480.5	62,598.0
Region	43,294.5	7,362.0	184,034.7	27,307.6	17,608.5	279,607.3	267,961.4	5,111.5	552,680.2
PACIFIC									
California	10,517.7	1,392.5	18,124.6	15,217.8	9,217.9	54,470.5	45,552.3	1,549.1	101,571.9
Oregon	4,356.4	1,965.9	9,392.0	11,889.2	1,728.6	29,332.1	32,121.5	673.0	62,126.6
Washington	7,793.4	1,344.6	5,637.0	12,690.3	2,626.4	30,091.7	12,474.3	1,042.7	43,608.7
Region	22,667.5	4,703.0	33,153.6	39,797.3	13,572.9	113,894.3	90,148.1	3,264.8	207,307.2
OTHER									
Hawaii	333.2	974.0	0.0	1,473.5		3,770.6	341.5	29.2	4,141.3
Caribbean	408.3	955.0	0.0	516.6	———	2,219.4	104.1	10.3	2,333.8
Region	741.5	1,929.0	0.0	1,990.1		5,990.0	445.6	39.5	6,475.1
TOTAL	421,402.5	133,310.6	405,913.7	393,713.4	141,986.0	1,497,655.6	404,166.8	38,237.8	1,940,060.1

Source: 1982 National Resources Inventory.

Appendix table 3a.--Capability classification of nonfederal rural land (1982), by state: Cropland

State	Land capability class								
	I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
NORTHEAST									
Connecticut	26.5	114.4	49.1	26.4	0.0	20.2	8.1	0.0	244.7
Delaware	80.6	250.3	176.7	9.7	1.1	0.7	0.0	0.0	519.1
Maine	57.2	537.1	216.1	120.6	0.0	20.8	1.6	0.0	953.4
Maryland	137.5	898.1	503.8	151.4	13.0	66.4	24.2	0.0	1,794.4
Massachusetts	21.5	122.4	81.7	27.6	12.1	31.4	0.5	0.0	297.2
New Hampshire	14.3	42.8	59.7	20.9	0.8	9.4	9.9	0.0	157.8
New Jersey	54.7	423.3	196.1	74.2	22.4	20.0	17.8	0.9	809.4
New York	220.6	2,381.3	2,571.7	579.8	56.5	91.3	10.9	0.0	5,912.1
Pennsylvania	191.9	2,344.7	2,181.0	805.0	15.4	251.1	106.4	0.8	5,896.3
Rhode Island	7.6	15.4	2.0	0.7	0.5	1.0	0.0	0.0	27.2
Vermont	22.8	213.5	244.2	128.5	4.4	31.1	2.9	1.0	648.4
APPALACHIA									
Kentucky	647.6	2,772.4	1,578.9	547.5	0.7	301.3	85.8	0.0	5,934.2
North Carolina	508.1	3,087.9	2,230.5	625.4	2.3	178.5	62.1	0.0	6,694.8
Tennessee	371.0	2,643.0	1,436.5	711.6	47.3	305.8	76.9	0.0	5,592.1
Virginia	278.2	1,781.7	791.6	345.1	12.5	137.0	50.8	0.0	3,396.9
West Virginia	34.2	425.1	262.5	190.3	10.7	99.6	68.5	2.2	1,093.1
SOUTHEAST									
Alabama	327.6	2,228.7	1,193.5	544.5	45.0	121.6	49.4	0.0	4,510.3
Florida	66.6	505.5	1,944.5	736.6	9.5	115.2	178.9	0.0	3,556.8
Georgia	726.5	4,136.4	876.6	635.3	96.3	69.3	28.0	0.0	6,568.4
South Carolina	505.5	1,945.6	821.2	246.7	2.7	45.2	11.8	0.0	3,578.7
LAKE STATES									
Michigan	22.7	5,545.8	3,019.0	604.8	38.3	169.5	43.0	0.0	9,443.1
Minnesota	2,051.5	14,074.5	4,749.4	1,856.0	34.1	200.3	58.3	0.0	23,024.1
Wisconsin	418.5	6,032.7	2,658.5	1,621.3	36.4	593.8	90.3	5.3	11,456.8
CORN BELT									
Illinois	3,971.5	14,514.1	4,493.8	1,205.9	64.3	423.3	54.5	0.0	24,727.4
Indiana	668.7	10,051.5	1,916.1	941.6	13.5	179.8	9.5	0.6	13,781.3
Iowa	3,085.6	13,645.9	7,296.0	1,726.8	71.4	456.2	158.8	0.0	26,440.7
Missouri	732.5	6,613.1	6,162.7	1,082.5	38.5	299.3	69.8	0.0	14,998.4
Ohio	262.6	8,503.7	3,013.3	492.1	8.5	149.2	17.7	0.0	12,447.1
DELTA STATES									
Arkansas	585.0	2,524.2	4,266.4	663.6	28.4	23.4	10.5	0.0	8,101.5
Louisiana	371.5	1,781.2	3,651.6	482.6	114.7	6.3	1.0	0.0	6,408.9
Mississippi	317.8	3,132.2	2,571.5	901.1	192.9	208.2	91.6	0.0	7,415.3
NORTHERN PLAINS									
Kansas	3,212.1	13,942.5	8,750.6	2,371.4	78.7	731.3	31.7	0.0	29,118.3
Nebraska	2,498.2	7,962.9	5,400.6	3,133.4	41.5	1,214.3	23.1	2.7	20,276.7
North Dakota	0.0	16,534.3	6,613.4	2,289.7	271.1	1,229.3	94.6	6.8	27,039.2
South Dakota	1,660.4	8,493.8	3,934.9	2,011.0	74.0	757.2	15.9	0.0	16,947.2
SOUTHERN PLAINS									
Oklahoma	1,242.9	4,301.6	3,866.7	1,639.3	108.4	398.0	11.2	0.0	11,568.1
Texas	1,014.6	14,378.4	13,981.0	2,685.7	345.7	798.9	115.3	0.0	33,319.6

Appendix table 3a.--Capability classification of nonfederal rural land (1982), by state: Cropland--continued

State	Land capability class I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
MOUNTAIN									
Arizona	771.3	201.6	199.0	28.1	0.0	6.0	0.3	0.0	1,206.3
Colorado	205.6	1,841.1	3,564.5	3,632.9	80.6	1,219.0	59.0	0.0	10,602.7
Idaho	110.8	1,983.9	2,524.6	1,281.1	54.3	359.1	74.7	1.6	6,390.1
Montana	0.0	516.3	11,711.1	3,409.1	83.3	1,188.5	288.6	0.0	17,196.9
Nevada	1.1	402.2	137.9	84.8	53.4	104.8	75.5	0.0	859.7
New Mexico	212.1	552.9	809.6	549.6	0.4	251.9	36.2	0.0	2,412.7
Utah	44.2	603.1	684.3	473.8	28.4	134.1	69.3	1.5	2,038.7
Wyoming	0.9	314.8	1,040.7	891.1	57.8	254.8	27.3	0.0	2,587.4
PACIFIC									
California	2,093.7	3,268.7	3,331.9	1,442.8	1.8	200.8	170.1	7.9	10,517.7
Oregon	159.1	1,226.1	1,986.6	721.4	72.0	147.3	43.9	0.0	4,356.4
Washington	146.8	1,280.6	3,775.6	2,099.4	11.1	381.9	95.3	2.7	7,793.4
OTHER									
Hawaii	31.0	98.8	95.6	67.1	0.0	14.0	26.7	0.0	333.2
Caribbean	25.9	68.3	49.9	45.0	0.0	87.2	131.5	0.5	408.3
Total	30,219.1	191,260.4	133,674.7	46,962.8	2,356.7	14,104.6	2,789.7	34.5	421,402.5

Source: 1982 National Resources Inventory.

Appendix table 3b.--Capability classification of nonfederal rural land (1982), by state: Pastureland

State	Land capability class								
	I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
NORTHEAST									
Connecticut	4.1	30.0	18.7	11.6	1.5	30.2	17.9	0.0	114.0
Delaware	3.0	13.5	12.6	3.6	0.6	0.7	1.2	0.0	35.2
Maine	7.4	219.6	146.1	114.0	0.0	62.7	15.4	3.8	569.0
Maryland	18.7	180.0	128.1	86.8	10.0	71.9	38.6	0.0	534.1
Massachusetts	1.8	62.3	45.0	14.7	6.3	39.3	31.7	0.5	201.6
New Hampshire	1.0	24.6	43.9	12.9	0.0	24.4	17.7	0.0	124.5
New Jersey	3.1	94.9	70.6	27.6	7.7	16.7	19.0	0.0	239.6
New York	52.6	894.2	1,675.8	624.4	148.2	289.9	186.7	0.0	3,871.8
Pennsylvania	43.5	616.2	916.7	533.3	8.7	183.2	291.0	0.0	2,592.6
Rhode Island	4.5	9.0	7.1	3.0	1.7	6.7	3.9	0.0	35.9
Vermont	3.0	87.1	136.2	94.5	7.5	76.2	95.2	1.0	500.7
APPALACHIA									
Kentucky	294.6	1,216.4	1,369.4	936.8	7.5	1,280.3	774.8	0.0	5,879.8
North Carolina	5.8	502.8	502.9	425.9	16.4	314.8	208.8	2.8	1,980.2
Tennessee	233.7	1,227.1	1,177.9	1,028.1	4.4	1,039.4	641.6	3.4	5,355.6
Virginia	33.7	757.7	829.8	791.4	22.8	498.7	456.7	1.2	3,392.0
West Virginia	9.8	213.5	243.4	328.3	9.3	500.1	556.6	8.1	1,869.1
SOUTHEAST									
Alabama	53.4	1,234.7	1,004.8	818.8	119.4	337.9	247.6	0.0	3,816.6
Florida	11.3	227.3	1,516.8	2,132.2	64.7	151.6	146.8	22.5	4,273.2
Georgia	47.6	1,081.3	751.9	679.7	98.8	199.6	117.7	0.0	2,976.6
South Carolina	19.9	450.8	460.8	169.4	3.9	72.0	31.2	0.0	1,208.0
LAKE STATES									
Michigan	7.8	692.4	1,041.3	520.6	152.9	406.9	79.7	9.4	2,911.0
Minnesota	41.2	1,132.2	814.2	660.0	186.7	503.1	237.3	15.1	3,589.8
Wisconsin	17.0	874.0	605.9	670.1	106.9	810.0	286.8	23.5	3,394.2
CORN BELT									
Illinois	142.3	1,158.2	671.3	421.8	26.4	557.5	175.1	4.7	3,157.3
Indiana	46.5	921.8	408.0	391.3	11.7	314.1	113.1	5.4	2,211.9
Iowa	102.7	1,263.7	1,253.4	812.4	117.8	538.1	448.0	0.0	4,536.1
Missouri	180.6	3,043.0	4,625.3	2,230.0	32.4	1,460.6	1,001.1	0.0	12,573.0
Ohio	31.1	762.8	712.1	592.5	6.9	433.2	175.3	0.0	2,713.9
DELTA STATES									
Arkansas	74.4	1,123.9	2,424.4	913.1	113.8	672.3	471.9	0.0	5,793.8
Louisiana	74.2	677.2	1,192.0	209.0	159.9	49.2	7.0	0.0	2,368.5
Mississippi	81.2	1,600.5	880.4	413.3	89.3	459.1	449.2	2.2	3,975.2
NORTHERN PLAINS									
Kansas	47.8	607.2	907.5	263.1	52.1	297.5	62.5	3.2	2,240.9
Nebraska	60.6	401.0	577.5	558.7	19.7	457.7	46.2	3.9	2,125.3
North Dakota	0.0	353.7	310.1	246.4	74.3	262.8	24.6	0.0	1,271.9
South Dakota	133.4	1,027.8	597.4	485.0	59.7	366.7	33.0	0.0	2,703.0
SOUTHERN PLAINS									
Oklahoma	202.0	2,204.9	1,543.7	1,072.3	371.5	1,318.2	422.8	2.5	7,137.9
Texas	324.0	4,137.3	6,657.5	2,542.3	1,770.0	1,483.0	128.7	0.0	17,042.8

Appendix table 3b.--Capability classification of nonfederal rural land (1982), by state: Pastureland--continued

State	Land capability class								
	I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
MOUNTAIN									
Arizona	18.2	7.2	10.1	13.3	22.1	6.0	2.4	0.0	79.3
Colorado	0.7	54.8	242.3	446.9	116.3	359.9	38.8	0.0	1,259.7
Idaho	8.2	152.2	306.1	408.0	134.1	168.2	92.0	5.4	1,274.2
Montana	0.0	90.6	1,210.0	813.3	75.9	743.9	89.8	12.5	3,036.0
Nevada	0.0	54.7	104.7	58.8	13.8	31.2	41.2	0.0	304.4
New Mexico	6.3	25.7	36.9	34.9	4.6	47.8	7.1	0.0	163.3
Utah	0.0	74.3	123.1	113.1	18.4	40.6	118.6	2.2	490.3
Wyoming	0.0	28.1	187.4	345.8	21.4	147.9	20.1	4.1	754.8
PACIFIC									
California	68.7	148.0	490.1	436.8	31.1	105.3	99.8	12.7	1,392.5
Oregon	19.3	414.5	508.1	451.6	97.4	353.9	118.7	2.4	1,965.9
Washington	9.1	251.7	454.2	359.5	30.1	209.3	30.7	0.0	1,344.6
OTHER									
Hawaii	0.0	20.7	157.1	138.4	0.0	143.5	458.0	56.3	974.0
Caribbean	12.6	53.7	113.4	128.5	0.0	167.7	459.6	19.5	955.0
Total	2,562.4	32,500.8	40,224.0	25,587.8	4,456.6	18,111.5	9,639.2	228.3	133,310.6

Source: 1982 National Resources Inventory.

Appendix table 3c.--Capability classification of nonfederal rural land (1982), by state: Rangeland

State	Land capability class I	II	III	IV	V	VI	VII	VIII	Total
	-----	-----	-----	-----	(1,000 acres)	-----	-----	-----	-----
NORTHEAST									
Connecticut	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Massachusetts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Hampshire	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New York	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pennsylvania	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhode Island	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vermont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
APPALACHIA									
Kentucky	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tennessee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
West Virginia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOUTHEAST									
Alabama	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Florida	0.0	6.1	999.5	2,165.2	83.3	140.0	401.1	8.7	3,803.9
Georgia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LAKE STATES									
Michigan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Minnesota	2.5	72.2	18.6	20.7	2.4	57.8	24.3	0.0	198.5
Wisconsin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CORN BELT									
Illinois	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iowa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Missouri	0.0	69.4	21.6	12.2	6.2	14.6	43.8	0.0	167.8
Ohio	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DELTA STATES									
Arkansas	0.0	2.5	15.3	20.1	0.0	35.8	90.9	0.0	164.6
Louisiana	1.0	0.7	24.2	16.2	2.0	0.0	160.5	36.7	241.3
Mississippi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NORTHERN PLAINS									
Kansas	127.5	2,457.1	3,784.9	1,693.2	438.0	7,226.1	1,156.1	26.0	16,908.9
Nebraska	36.1	689.1	1,233.2	2,694.9	564.5	13,761.3	4,060.7	55.9	23,095.7
North Dakota	0.0	1,718.0	1,886.1	1,418.3	508.2	3,690.2	1,686.7	40.9	10,948.4
South Dakota	78.1	2,592.8	3,110.3	3,722.5	313.6	9,331.5	3,634.8	0.0	22,783.6
SOUTHERN PLAINS									
Oklahoma	118.9	1,303.1	2,337.4	2,686.2	498.4	5,744.0	2,357.0	14.6	15,059.6
Texas	146.1	7,334.4	17,568.1	11,945.8	2,659.8	20,668.4	34,867.3	163.2	95,353.1

Appendix table 3c.--Capability classification of nonfederal rural land (1982), by state: Rangeland--continued

State	Land capability class								
	I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
MOUNTAIN									
Arizona	0.0	0.0	1.5	54.5	0.0	12,188.5	18,479.8	223.9	30,948.2
Colorado	0.0	205.2	1,458.5	5,535.6	203.3	11,279.8	5,128.4	411.7	24,222.5
Idaho	0.0	14.7	507.3	1,026.7	99.2	2,309.9	2,706.0	69.1	6,732.9
Montana	0.0	15.1	8,758.3	7,766.7	148.9	12,225.6	8,590.4	332.0	37,837.0
Nevada	0.0	10.5	3.2	6.5	35.5	1,977.7	5,850.1	24.3	7,907.8
New Mexico	0.0	11.3	604.7	2,576.8	2.2	16,415.3	21,069.5	302.1	40,981.9
Utah	0.1	5.7	105.0	290.4	33.8	2,164.4	5,796.2	93.7	8,489.3
Wyoming	0.0	7.7	1,699.2	4,486.5	136.2	11,280.0	8,808.9	496.6	26,915.1
PACIFIC									
California	3.0	117.5	1,074.6	3,180.9	11.6	4,426.7	8,367.2	943.1	18,124.6
Oregon	1.6	87.8	488.9	782.2	144.3	2,823.6	5,021.6	42.0	9,392.0
Washington	0.0	26.4	688.3	983.0	5.2	1,350.5	2,523.2	60.4	5,637.0
OTHER									
Hawaii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caribbean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	514.9	16,747.3	46,388.7	53,085.1	5,896.6	139,111.7	140,824.5	3,344.9	405,913.7

Source: 1982 National Resources Inventory.

Appendix table 3d.--Capability classification of nonfederal rural land (1982), by state: Forest land

State	Land capability class								
	I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
NORTHEAST									
Connecticut	14.7	134.3	85.4	70.3	81.9	408.8	1,012.3	20.6	1,828.3
Delaware	4.9	47.1	244.3	18.2	0.0	2.7	30.4	0.0	347.6
Maine	11.8	1,172.3	1,166.0	1,404.0	74.5	6,730.9	5,326.6	884.2	16,770.3
Maryland	25.6	392.0	742.0	256.6	141.8	403.6	456.2	7.5	2,425.3
Massachusetts	16.0	163.4	209.0	107.9	219.5	477.4	1,774.2	2.7	2,970.1
New Hampshire	5.4	118.7	349.9	312.1	6.2	1,749.9	1,470.3	72.8	4,085.1
New Jersey	44.7	382.1	322.3	245.4	155.5	137.3	523.3	37.8	1,848.4
New York	103.2	1,693.1	3,868.0	2,324.7	642.6	3,715.8	4,116.4	53.1	16,516.9
Pennsylvania	62.1	1,644.2	2,481.1	1,510.0	24.9	3,442.0	5,974.8	161.2	15,300.3
Rhode Island	5.9	36.2	31.4	28.2	27.9	175.6	100.3	0.0	405.5
Vermont	3.1	111.1	365.9	365.6	45.5	1,489.2	1,642.7	63.4	4,086.5
APPALACHIA									
Kentucky	141.0	413.7	733.9	868.5	9.2	1,586.7	6,405.2	0.0	10,158.2
North Carolina	90.4	2,788.1	4,030.4	2,797.7	657.7	2,497.4	3,794.8	72.0	16,728.5
Tennessee	90.6	1,024.1	1,612.0	1,348.3	131.7	2,065.5	5,245.1	11.8	11,529.1
Virginia	144.9	3,262.8	2,222.4	1,834.9	336.1	2,150.1	3,651.0	23.1	13,625.3
West Virginia	18.0	214.8	451.8	916.5	10.4	1,559.1	7,120.9	131.0	10,422.5
SOUTHEAST									
Alabama	153.9	2,336.6	2,706.6	3,774.7	1,777.7	2,675.6	7,194.7	13.5	20,633.3
Florida	19.4	945.6	3,633.0	4,430.1	1,101.7	865.7	1,378.1	56.5	12,430.1
Georgia	139.8	3,581.7	3,401.4	5,499.1	3,400.2	3,116.0	2,738.0	7.4	21,883.6
South Carolina	87.0	2,063.0	3,997.4	1,750.7	102.5	1,661.6	1,362.5	0.8	11,025.5
LAKE STATES									
Michigan	8.2	1,920.0	2,940.7	2,671.2	1,789.1	4,535.7	1,441.1	53.7	15,359.7
Minnesota	29.7	3,343.3	2,105.1	2,964.8	553.6	2,015.4	2,915.6	28.8	13,956.3
Wisconsin	22.7	2,380.8	1,896.5	2,745.5	411.9	4,055.1	1,752.7	127.6	13,392.8
CORN BELT									
Illinois	65.9	843.0	540.5	416.1	90.3	829.4	636.1	8.1	3,429.4
Indiana	77.9	1,017.3	473.5	540.5	37.3	598.4	886.3	8.7	3,639.9
Iowa	29.2	245.1	264.3	192.6	146.8	247.5	629.1	1.6	1,756.2
Missouri	140.5	829.1	1,866.8	1,602.1	25.0	1,876.5	4,640.7	4.9	10,985.6
Ohio	34.5	1,067.8	1,354.2	1,132.6	16.1	1,332.8	1,439.7	2.5	6,380.2
DELTA STATES									
Arkansas	96.9	1,682.0	3,754.4	2,057.2	1,270.4	2,115.4	3,363.5	0.0	14,339.8
Louisiana	42.1	1,825.1	5,218.4	1,596.9	2,237.6	685.1	1,231.8	58.0	12,895.0
Mississippi	98.3	2,676.6	1,939.2	1,941.7	1,577.2	2,344.7	4,655.3	9.7	15,242.7
NORTHERN PLAINS									
Kansas	33.7	176.0	71.3	23.0	71.7	150.2	94.0	6.3	626.2
Nebraska	10.9	75.1	36.6	37.4	22.1	244.1	283.0	22.9	732.1
North Dakota	0.0	109.6	86.7	36.2	3.9	144.6	52.9	4.3	438.2
South Dakota	5.0	21.7	22.1	17.7	0.0	199.4	295.7	0.0	561.6
SOUTHERN PLAINS									
Oklahoma	25.0	376.1	346.0	614.8	394.1	1,462.3	3,320.4	0.0	6,538.7
Texas	4.6	1,856.8	2,749.6	1,512.8	1,266.3	1,813.1	120.4	0.0	9,323.6

Appendix table 3d.--Capability classification of nonfederal rural land (1982), by state: Forest land--continued

State	Land capability class								
	I	II	III	IV	V	VI	VII	VIII	Total
	(1,000 acres)								
MOUNTAIN									
Arizona	0.0	0.0	0.0	114.6	0.0	2,620.1	2,025.5	0.0	4,760.2
Colorado	0.0	1.6	5.1	89.3	23.3	1,142.7	2,660.8	107.3	4,030.1
Idaho	0.0	5.8	79.9	595.3	4.1	955.5	2,289.5	47.0	3,977.1
Montana	0.0	5.5	85.3	322.4	28.5	2,468.8	2,275.4	42.1	5,228.0
Nevada	0.0	0.0	0.0	0.0	0.0	21.7	334.3	0.6	356.6
New Mexico	0.0	0.0	0.0	13.1	0.0	1,389.2	3,331.6	0.0	4,733.9
Utah	0.0	0.0	8.2	12.2	0.0	660.4	2,459.0	94.8	3,234.6
Wyoming	0.0	0.0	2.3	34.1	5.7	447.0	474.7	23.3	987.1
PACIFIC									
California	5.0	30.3	424.5	2,196.7	0.0	5,638.5	6,553.8	389.0	15,217.8
Oregon	17.2	176.7	481.7	866.1	0.0	6,478.8	3,826.1	42.6	11,889.2
Washington	0.7	411.1	1,895.4	3,255.3	49.3	4,280.3	2,744.0	54.2	12,690.3
OTHER									
Hawaii	0.0	10.3	78.1	156.3	0.0	71.0	786.8	371.0	1,473.5
Caribbean	0.0	1.4	10.4	19.6	0.0	71.0	354.0	60.2	516.6
Total	1,930.4	43,613.0	61,391.0	57,641.6	18,971.8	87,805.6	119,171.6	3,188.4	393,713.4

Source: 1982 National Resources Inventory.

Appendix table 4.--Nonfederal land, by subclass and classes I, V & VIII

Farming region and state	Land capability subclass e	w	s	c	(columns 1-4)	Land Capability Class I	V & VIII 1/	Other 2/ land	Grand total (columns 5-8)
NORTHEAST									
Connecticut	225.2	225.2	1,676.8	0.0	2,127.5	52.4	148.8	779.8	3,108.5
Delaware	185.3	424.3	231.1	0.0	840.7	89.	94.1	179.7	1,203.5
Maine	2,689.8	2,668.1	12,297.3	0.0	17,655.2	76.4	1,212.7	757.4	19,701.7
Maryland	2,430.3	1,317.8	776.7	0.0	4,524.8	184.2	396.3	1,008.6	6,113.9
Massachusetts	259.7	381	2,719.9	0.0	3,360.6	39.9	373.	1,149.6	4,923.1
New Hampshire	736.4	314.4	3,251.4	77.1	4,379.3	26.	156.9	471.	5,033.2
New Jersey	723.5	1,002.5	976.6	1.5	2,704.1	105.5	474.2	1,351.1	4,634.9
New York	11,096.2	7,147.3	7,303.	0.0	25,546.5	389.6	1,089.	3,058.6	30,083.7
Pennsylvania	12,549.8	3,386.3	8,333.8	0.0	24,269.9	314.7	257.3	3,217.8	28,059.7
Rhode Island	31.5	64.9	338.9	0.0	435.3	18.3	43.8	174.1	671.5
Vermont	1,793.6	518.1	2,827.4	3.1	5,142.2	29.2	143.5	304.3	5,619.2
Subtotal	32,721.3	17,450.2	40,732.9	81.7	90,986.1	1,325.2	4,389.6	12,452.	109,152.9
APPALACHIA									
Kentucky	17,027.	1,862.2	2,730.7	0.0	21,619.9	1,105.2	31.9	1,521.	24,278.
North Carolina	12,869.6	8,954.3	2,859.1	0.6	24,683.6	618.2	912.6	2,896.2	29,110.6
Tennessee	13,861.1	3,029.1	5,208.3	0.0	22,098.5	710.3	248.6	1,922.5	24,979.9
Virginia	14,078.	2,685.1	3,277.7	0.0	20,040.8	472.4	586.8	1,962.6	23,062.6
West Virginia	7,738.7	516.8	5,158.9	0.0	13,409.4	64.2	194.	662.3	14,329.9
Subtotal	65,574.4	17,047.5	19,229.7	0.6	101,852.2	2,970.3	1,973.9	8,964.6	115,761.
SOUTHEAST									
Alabama	17,929.3	4,242.6	4,807.6	0.0	26,979.4	550.4	1,986.9	2,036.7	31,553.4
Florida	1,226.7	17,773.7	6,233.9	0.0	2,523.3	97.3	2,286.	3,910.6	31,528.2
Georgia	15,880.9	6,697.6	4,884.2	0.0	27,462.7	935.5	3,986.4	2,693.5	35,078.1
South Carolina	6,233.4	6,393.8	2,783.7	0.0	15,410.9	624.7	502.4	1,635.2	18,173.2
Subtotal	41,270.3	35,107.7	18,709.3	0.0	95,087.3	2,207.9	8,761.7	10,276.	116,332.9
LAKE STATES									
Michigan	8,951.2	9,968.4	8,223.8	0.0	27,143.4	38.7	2,699.2	3,486.9	33,368.2
Minnesota	13,742.3	20,174.8	6,267.1	968.	41,152.2	2,238.9	1,542.8	2,523.4	47,457.3
Wisconsin	15,110.9	8,291.7	5,908.	0.0	29,310.6	458.2	913.3	2,381.9	33,064.
Subtotal	37,804.4	38,434.9	20,398.9	968.	97,606.2	2,735.8	5,155.3	8,392.2	113,889.5
CORN BELT									
Illinois	14,351.	11,927.1	1,146.2	0.0	27,424.3	4,261.1	251.5	3,200.3	35,137.2
Indiana	8,539.4	9,582.4	1,345.3	0.0	19,467.1	806.3	172.4	2,067.7	22,513.5
Iowa	19,008.4	9,417.6	1,519.4	0.0	29,945.4	3,328.1	382.1	1,988.	35,643.6
Missouri	18,956.	6,819.	12,423.5	0.0	38,228.5	1,070.1	133.	2,551.7	41,983.3
Ohio	12,308.1	9,118.9	748.8	0.0	22,175.8	340.2	80.3	3,295.7	25,892.
Subtotal	73,162.9	46,895.	17,183.2	0.0	137,241.1	9,805.8	1,019.3	13,103.4	161,169.6

Appendix table 4.--Nonfederal land, by subclass and classes I, V & VIII--continued

Farming region and state	Land capability subclass				(columns 1-4)	Land Capability Class		Other 2/ land	Grand total (columns 5-8)
	e	w	s	c		I	V & VIII 1/		
DELTA STATES									
Arkansas	12,205.7	10,136.2	4,157.9	0.0	26,499.8	756.3	1,468.8	1,495.6	30,220.5
Louisiana	7,279.6	12,367.	354.8	0.0	20,001.4	520.2	4,626.3	1,954.6	27,102.5
Mississippi	15,006.	8,964.5	544.1	0.0	24,514.6	514.1	1,958.4	1,570.4	28,557.5
Subtotal	34,491.3	31,467.7	5,056.8	0.0	71,015.8	1,790.6	8,053.5	5,020.6	85,880.5
NORTHERN PLAINS									
Kansas	32,935.	3,182.2	3,480.3	5,826.5	45,424.	3,459.8	721.	2,179.9	51,784.7
Nebraska	34,871.3	3,826.3	3,025.2	1,781.	43,503.8	2,666.8	795.7	1,483.1	48,449.4
North Dakota	26,305.5	2,896.1	4,667.5	5,901.3	39,770.4	0.0	1,228.7	1,434.6	42,433.7
South Dakota	26,562.2	2,749.5	7,363.2	4,606.6	41,281.5	1,954.1	1,258.1	1,268.1	45,761.8
Subtotal	120,674.0	12,654.1	18,536.2	18,115.4	169,979.7	8,080.7	4,003.5	6,365.7	188,429.6
SOUTHERN PLAINS									
Oklahoma	24,512.4	2,918.	8,908.5	1,357.7	3,769.6	1,601.	1,427.8	2,057.3	42,782.7
Texas	74,726.3	14,729.5	49,524.9	9,525.6	148,506.3	1,502.7	7,193.9	7,562.4	164,765.3
Subtotal	99,238.7	17,647.5	58,433.4	10,883.3	186,202.9	3,103.7	8,621.7	9,619.7	207,548.0
MOUNTAIN									
Arizona	8,489.2	447.8	22,346.2	4,871.6	36,154.8	789.5	2,623.3	1,035.8	40,603.4
Colorado	29,538.2	1,401.8	5,532.	2,952.2	39,424.2	208.5	1,537.8	1,525.8	42,696.3
Idaho	12,171.7	995.1	3,315.9	1,686.2	18,168.9	120.1	617.9	542.5	19,449.4
Montana	52,540.3	2,127.2	8,381.7	129.9	63,179.1	0.0	1,465.	1,303.	65,947.1
Nevada	932.1	1,364.6	5,837.9	1,302.5	9,437.1	1.1	343.2	377.1	10,158.5
New Mexico	32,730.2	456.1	14,360.8	926.7	48,473.8	222.2	1,795.	756.	51,247.
Utah	7,249.2	925.2	5,245.7	698.8	14,116.9	45.8	2,061.1	479.3	16,703.1
Wyoming	25,040.3	1,044.5	4,100.	496.4	30,681.2	0.9	1,542.7	577.7	32,602.5
Subtotal	168,691.2	8,762.3	69,120.2	13,062.3	259,636.	1,388.1	11,986.	6,597.2	279,407.3
PACIFIC									
California	28,744.3	3,687.1	9,894.6	702.9	43,028.9	2,188.4	4,407.7	4,845.5	54,470.5
Oregon	15,336.9	2,299.7	9,229.4	476.8	27,342.8	203.7	684.7	1,100.9	29,332.1
Washington	20,529.1	2,003.8	4,622.1	392.1	27,547.1	160.3	671.7	1,712.6	30,091.7
Subtotal	64,610.3	7,990.6	23,746.1	1,571.8	97,918.8	2,552.4	5,764.1	7,659.	113,894.3
TOTAL	787,544.5	440,088.8	291,146.7	44,683.1	1,307,526.1	35,960.5	59,728.6	88,450.4	1,491,465.6

1/ Data on subclasses of land in classes V and VIII were not collected for the 1982 NRI.
2/ Data on capability classification were collected only for rural agricultural land.

Source: 1982 NRI.

Appendix table 5.--Prime farmland, by state

State	Cropland	Pastureland	Rangeland	Forest land	Minor land cover/uses	Total
			(1,000 acres)			
NORTHEAST						
Connecticut	141.7	35.0	0.0	148.4	29.9	355.0
Delaware	327.4	22.3	0.0	68.3	12.9	430.9
Maine	388.5	135.2	0.0	679.2	70.8	1,273.7
Maryland	839.1	125.5	0.0	250.9	33.9	1,249.4
Massachusetts	138.8	62.0	0.0	165.9	15.0	381.7
New Hampshire	43.5	12.6	0.0	71.5	16.8	144.4
New Jersey	448.6	82.1	0.0	294.7	38.1	863.5
New York	2,732.8	950.3	0.0	1,380.6	74.6	5,138.3
Pennsylvania	2,181.5	537.8	0.0	1,412.7	153.3	4,285.3
Rhode Island	23.0	13.5	0.0	41.1	1.0	78.6
Vermont	171.4	67.0	0.0	91.5	6.1	336.0
APPALACHIA						
Kentucky	3,757.0	1,505.6	0.0	615.8	172.3	6,050.7
North Carolina	2,808.0	479.1	0.0	2,179.2	213.3	5,679.6
Tennessee	3,415.6	1,570.0	0.0	1,203.1	128.9	6,317.6
Virginia	1,757.4	522.8	0.0	2,648.6	103.9	5,032.7
West Virginia	319.4	108.7	0.0	99.3	11.7	539.1
SOUTHEAST						
Alabama	2,889.8	1,497.1	0.0	2,749.6	134.3	7,270.8
Florida	419.7	152.1	0.4	520.3	12.3	1,104.8
Georgia	3,883.6	980.5	0.0	2,673.4	190.8	7,728.3
South Carolina	1,660.7	392.0	0.0	1,290.4	85.8	3,428.9
LAKE STATES						
Michigan	5,707.5	687.5	0.0	1,187.4	216.5	7,798.9
Minnesota	16,051.1	1,096.9	73.0	2,992.6	624.4	20,838.0
Wisconsin	6,288.2	790.3	0.0	2,117.6	218.3	9,414.4
CORN BELT						
Illinois	19,089.0	1,147.2	0.0	679.4	337.7	21,253.3
Indiana	11,190.6	915.1	0.0	1,027.2	377.7	13,510.6
Iowa	16,683.9	1,245.0	0.0	224.5	529.6	18,683.0
Missouri	9,863.3	3,760.8	73.9	1,104.9	197.2	15,000.1
Ohio	9,764.2	791.4	0.0	1,234.5	458.2	12,248.3

Appendix table 5.--Prime farmland, by state--continued

State	Cropland	Pastureland	Rangeland	Forest land	Minor land cover/uses	Total
			(1,000 acres)			
DELTA STATES						
Arkansas	6,641.4	2,226.0	4.8	2,675.4	76.9	11,624.5
Louisiana	5,653.6	1,592.5	15.0	5,488.0	226.3	12,975.4
Mississippi	5,354.7	1,781.1	0.0	3,088.1	116.8	10,340.7
NORTHERN PLAINS						
Kansas	19,007.0	1,345.4	4,665.3	251.4	333.3	25,602.4
Nebraska	10,600.2	541.5	692.1	85.2	324.2	12,243.2
North Dakota	12,682.7	249.1	602.4	72.7	306.0	13,912.9
South Dakota	5,348.9	428.1	414.1	14.6	220.6	6,426.3
SOUTHERN PLAINS						
Oklahoma	7,908.9	3,336.8	3,014.8	667.5	121.0	15,049.0
Texas	19,229.8	5,526.1	10,198.1	2,321.6	345.7	37,621.3
MOUNTAIN						
Arizona	1,059.8	31.0	0.0	0.0	0.0	1,090.8
Colorado	1,596.7	74.2	0.0	0.0	15.3	1,686.2
Idaho	3,036.6	272.9	55.5	11.5	36.9	3,413.4
Montana	857.9	138.9	4.6	1.3	12.2	1,014.9
Nevada	285.1	23.3	2.1	0.0	3.0	313.5
New Mexico	573.9	37.4	0.0	0.0	3.8	615.1
Utah	732.6	51.6	0.7	0.0	2.6	787.5
Wyoming	293.4	24.1	21.3	0.0	10.6	349.4
PACIFIC						
California	5,544.7	256.4	44.9	5.2	39.8	5,891.0
Oregon	1,340.5	359.3	36.6	156.7	42.4	1,935.5
Washington	1,418.5	353.1	8.4	454.0	74.0	2,308.0
OTHER						
Caribbean	122.1	137.6	0.0	3.9	1.3	264.9
Hawaii	243.4	43.3	0.0	9.8	0.0	296.5
TOTAL	232,517.7	38,515.1	19,928.0	44,459.5	6,778.0	342,198.3

Source: 1982 National Resources Inventory.

Appendix table 6.-- Nonfederal land with high or medium potential for conversion to cropland

Farming region and state	Pastureland		Rangeland		Forest land		Total	
	High	Medium	High	Medium	High	Medium	High	Medium
	(1,000 acres)							
NORTHEAST								
Connecticut	26.8	41.9	0.0	0.0	40.9	181.3	67.7	223.2
Delaware	11.4	13.7	0.0	0.0	23.6	205.0	35.0	218.7
Maine	60.9	164.4	0.0	0.0	80.9	423.9	141.8	588.3
Maryland	70.4	129.1	0.0	0.0	48.9	258.2	119.3	387.3
Massachusetts	20.4	64.2	0.0	0.0	14.6	98.7	35.0	162.9
New Hampshire	22.1	18.9	0.0	0.0	6.9	93.5	29.0	112.4
New Jersey	15.7	42.9	0.0	0.0	33.1	129.4	48.8	172.3
New York	285.6	1,381.0	0.0	0.0	61.5	738.8	347.1	2,119.8
Pennsylvania	342.9	793.6	0.0	0.0	198.3	1,065.2	541.2	1,858.8
Rhode Island	2.0	4.4	0.0	0.0	0.0	21.1	2.0	25.5
Vermont	64.0	118.8	0.0	0.0	36.7	136.6	100.7	255.4
Region	922.2	2,772.9	0.0	0.0	545.4	3,351.7	1,467.6	6,124.6
APPALACHIA								
Kentucky	969.4	1,608.6	0.0	0.0	150.0	522.4	1,119.4	2,131.0
North Carolina	275.7	707.5	0.0	0.0	1,150.3	4,155.6	1,426.0	4,863.1
Tennessee	1,040.5	1,450.2	0.0	0.0	402.0	1,044.4	1,442.5	2,494.6
Virginia	233.0	823.7	0.0	0.0	278.4	1,996.8	511.4	2,820.5
West Virginia	112.1	547.4	0.0	0.0	24.5	605.4	136.6	1,152.8
Region	2,630.7	5,137.4	0.0	0.0	2,005.2	8,324.5	4,635.9	13,461.9
SOUTHEAST								
Alabama	814.5	1,477.3	0.0	0.0	498.7	2,287.3	1,313.2	3,764.6
Florida	419.5	1,658.9	86.5	1,009.3	185.4	1,020.7	691.4	3,688.9
Georgia	546.5	979.3	0.0	0.0	774.5	2,438.9	1,321.0	3,418.2
South Carolina	120.1	416.2	0.0	0.0	117.0	1,070.1	237.1	1,486.3
Region	1,900.6	4,531.7	86.5	1,009.3	1,575.6	6,817.0	3,562.7	12,357.9
LAKE STATES								
Michigan	438.8	856.0	0.0	0.0	237.6	1,465.1	676.4	2,321.1
Minnesota	686.2	1,119.0	10.9	37.1	401.0	2,060.3	1,098.1	3,216.4
Wisconsin	531.4	805.1	0.0	0.0	202.2	1,265.4	733.6	2,070.5
Region	1,656.4	2,780.1	10.9	37.1	840.8	4,790.8	2,508.1	7,608.0
CORNBELT								
Illinois	469.3	860.9	0.0	0.0	142.2	480.6	611.5	1,341.5
Indiana	420.2	638.8	0.0	0.0	229.8	578.4	650.0	1,217.2
Iowa	783.7	1,457.7	0.0	0.0	45.9	219.7	829.6	1,677.4
Missouri	2,367.1	4,690.6	47.8	32.4	270.7	1,216.0	2,685.6	5,939.0
Ohio	388.8	718.5	0.0	0.0	249.4	829.4	638.2	1,547.9
Region	4,429.1	8,366.4	47.8	32.4	938.0	3,324.1	5,414.9	11,722.9

Appendix table 6.-- Nonfederal land with high or medium potential for conversion to cropland--continued

Farming region and state	Pastureland		Rangeland		Forest land		Total	
	High	Medium	High	Medium	High	Medium	High	Medium
	(1,000 acres)							
DELTA STATES								
Arkansas	438.5	1,745.9	2.5	7.3	251.3	979.0	692.3	2,732.2
Louisiana	446.0	743.6	0.7	11.0	390.2	1,733.5	836.9	2,488.1
Mississippi	630.2	1,129.8	0.0	0.0	400.0	1,333.1	1,030.2	2,462.9
Region	1,514.7	3,619.3	3.2	18.3	1,041.5	4,045.6	2,559.4	7,683.2
NORTHERN PLAINS								
Kansas	416.3	878.3	1,139.4	3,217.1	15.5	68.7	1,571.2	4,164.1
Nebraska	378.9	777.4	645.6	3,724.0	19.3	58.0	1,043.8	4,559.4
North Dakota	230.5	422.1	467.5	1,935.6	17.7	84.5	715.7	2,442.2
South Dakota	581.8	1,204.0	689.1	3,688.6	1.3	4.9	1,272.2	4,897.5
Region	1,607.5	3,281.8	2,941.6	12,565.2	53.8	216.1	4,602.9	16,063.1
SOUTHERN PLAINS								
Oklahoma	733.1	2,134.3	727.6	2,514.9	42.6	364.9	1,503.3	5,014.1
Texas	1,390.3	4,666.0	2,490.0	11,273.7	35.4	449.6	3,915.7	16,389.3
Region	2,123.4	6,800.3	3,217.6	13,788.6	78.0	814.5	5,419.0	21,403.4
MOUNTAIN								
Arizona	42.3	32.0	329.7	1,703.3	0.0	2.2	372.0	1,737.5
Colorado	84.1	232.6	277.1	1,775.7	1.6	17.7	362.8	2,026.0
Idaho	118.1	417.0	114.4	386.9	23.7	139.9	256.2	943.8
Montana	438.2	1,023.2	753.4	3,668.8	2.2	47.3	1,193.8	4,739.3
Nevada	16.4	77.1	46.5	169.9	0.0	0.0	62.9	247.0
New Mexico	19.1	32.1	177.9	947.8	0.0	0.1	197.0	980.0
Utah	28.2	142.1	39.0	191.6	0.0	3.3	67.2	337.0
Wyoming	96.2	313.8	185.8	1,444.3	0.5	2.7	282.5	1,760.8
Region	842.6	2,269.9	1,923.8	10,288.3	28.0	213.2	2,794.4	12,771.4
PACIFIC								
California	210.7	423.7	318.0	1,123.0	23.8	86.3	552.5	1,633.0
Oregon	244.3	503.5	67.4	612.5	11.1	177.0	322.8	1,293.0
Washington	177.3	512.6	147.6	539.1	109.3	1,574.2	434.2	2,625.9
Region	632.3	1,439.8	533.0	2,274.6	144.2	1,837.5	1,309.5	5,551.9
OTHER								
Hawaii	29.4	58.2	0.0	0.0	12.2	24.3	41.6	82.5
Puerto Rico	62.1	147.2	0.0	0.0	0.4	39.5	62.5	186.7
Region	91.5	205.4	0.0	0.0	12.6	63.8	104.1	269.2
TOTAL	18,350.9	41,205.0	8,764.4	40,013.9	7,263.1	33,798.8	34,378.8	115,017.9

This table does not include data on land in minor cover types and uses.
Source: 1982 National Resources Inventory.

Appendix table 7.--Cropland and land with potential for conversion to cropland, by land capability class and subclass

Class and subclass	Potential for conversion to cropland					Cropland in 1982	Total
	High	Medium	Low	Zero	Total		
	(1,000 acres)						
I	1,731.3	1,512.4	2,025.6	541.6	5,810.9	30,219.1	36,030.0
IIe	9,842.2	18,856.7	22,525.4	5,235.8	56,460.1	91,363.1	147,823.2
IIw	4,999.0	8,569.1	14,338.8	3,448.7	31,355.6	64,951.8	96,307.4
IIs	1,157.2	2,457.3	2,559.9	623.6	6,816.0	17,187.0	24,003.0
IIc	1,038.5	1,670.0	1,780.5	429.1	4,918.1	17,758.5	22,676.6
Subtotal	17,036.9	31,571.1	41,204.6	9,737.2	99,549.8	191,260.4	290,810.2
IIIe	7,602.4	30,626.1	50,253.2	11,960.2	100,441.9	82,720.3	183,162.2
IIIw	2,784.1	8,571.2	19,419.3	5,196.4	35,971.0	33,291.7	69,262.7
IIIs	848.6	3,922.9	8,999.9	2,102.6	15,874.0	12,498.1	28,372.1
IIIc	356.7	771.6	1,187.1	229.5	2,544.9	5,164.6	7,709.5
Subtotal	11,591.8	43,891.8	19,859.5	19,488.7	154,831.8	133,674.7	288,506.5
I-III	30,360.0	76,975.3	123,089.3	29,767.5	260,192.5	355,154.2	615,346.7
IVe	1,983.0	16,477.1	54,427.5	18,791.3	91,678.9	32,479.2	124,158.1
IVw	656.8	4,927.6	15,484.5	5,010.7	26,079.6	7,191.3	33,270.9
IVs	492.6	3,862.5	12,149.9	3,903.8	20,408.8	6,821.9	21,280.7
IVc	42.2	517.3	876.3	159.9	1,595.7	470.4	2,066.1
Subtotal	3,174.6	25,784.5	82,938.2	27,865.7	139,763.0	46,962.8	186,725.8
I-IV	33,534.6	102759.8	206,027.9	57,633.2	399,955.5	402,117.0	802,072.5
V	319.5	2,368.3	16,329.5	12,283.9	31,301.2	2,356.7	33,657.9
VIe	427.8	6,803.4	70,117.6	81,218.2	158,567.0	9,928.6	168,495.6
VIw	180.9	1,059.7	9,405.8	8,448.7	19,095.1	1,181.0	20,276.1
VIs	360.6	2,645.9	30,671.7	32,793.6	66,471.8	2,801.3	69,273.1
VIc	208.9	565.5	4,181.7	1,902.2	6,858.3	193.7	7,052.0
Subtotal	1,178.2	11,074.5	114,376.8	124,362.7	250,992.2	14,104.6	265,096.8
VIIe	4.3	84.2	284.3	115,105.0	115,477.8	1,303.6	116,781.4
VIIw	0.0	0.0	0.0	14,201.7	14,201.7	298.6	14,500.3
VIIs	95.7	416.7	561.6	141,999.9	143,073.9	1,123.2	144,197.1
VIIc	201.9	936.8	3,105.9	991.6	5,236.2	64.3	5,300.5
Subtotal	301.9	1,437.7	3,951.8	272,298.2	277,989.6	2,789.7	280,779.3
VIII	0.0	0.0	0.0	27,113.0	27,113.0	34.5	27,147.5
V-VIII	1,799.6	14,880.5	134,658.1	436,057.8	587,396.0	19,285.5	606,681.5
NA	0.0	0.0	0.0	5,222.7	5,222.7	0.0	5,222.7
Total	35,334.2	117,640.3	340,686.0	498,913.7	992,574.2	421,402.5	1,413,976.7

Source: 1982 National Resources Inventory.

The following tables show erosion as estimated by the Universal Soil Loss Equation (USLE) and Wind Erosion Equation (WEQ).

The USLE is a model designed to predict the long-term average annual sheet and rill erosion under specified conditions. It does not predict gully, "ephemeral gully," streambank or streambed erosion nor does it predict offsite sediment delivery. The basic factors in the equation are rainfall, soil erodibility, slope length and steepness, vegetative cover, and supporting conservation practices--terraces, contour farming, and strip-cropping.

The Wind Erosion Equation is a model designed to estimate average erosion by wind. The basic factors in the equation are soil erodibility, soil ridge roughness, climate, field length along the prevailing wind direction, and vegetative cover.

Many of the tables show erosion rates in terms of soil loss tolerance (T). The goal of good soil management is to ensure that erosion does not exceed a rate that will permit a high level of production economically and indefinitely. T values represent an estimate of what that rate is for specific soils. T values range from 1 ton to 5 tons per acre per year; about 70 percent of cropland soils have a T value of 5. Research, including computer simulation, indicates that currently-assigned T values may be too low on some soils and too high on others. USDA is conducting research to improve all of the tools and methods used to estimate erosion and quantify its effects on specific soils.

Appendix table 8.--Estimated average annual erosion (1982) on nonfederal rural land (except small built-up land) by state

State	Wind erosion		Sheet and rill erosion	
	1,000 tons	tons/acre	1,000 tons	tons/acre
NORTHEAST				
Connecticut	0.0	0.0	1,255.3	0.5
Delaware	1,125.0	1.1	1,132.8	1.1
Maine	0.0	0.0	3,856.4	0.2
Maryland	456.2	0.1	12,055.1	2.4
Massachusetts	0.0	0.0	1,462.4	0.4
New Hampshire	0.0	0.0	1,079.7	0.2
New Jersey	322.0	0.1	5,973.9	1.8
New York	0.0	0.0	23,809.5	0.9
Pennsylvania	0.0	0.0	84,245.3	3.4
Rhode Island	0.0	0.0	209.2	0.4
Vermont	0.0	0.0	2,830.3	0.5
APPALACHIA				
Kentucky	0.0	0.0	147,596.9	6.5
North Carolina	0.0	0.0	60,691.4	2.3
Tennessee	0.0	0.0	80,762.2	3.5
Virginia	721.6	0.0	47,777.8	2.3
West Virginia	0.0	0.0	45,927.7	3.4
SOUTHEAST				
Alabama	0.0	0.0	90,880.4	3.1
Florida	4,244.9	0.2	10,995.9	0.4
Georgia	0.0	0.0	51,294.8	1.6
South Carolina	0.0	0.0	14,539.1	1.1
LAKE STATES				
Michigan	15,805.5	0.5	26,934.7	0.9
Minnesota	90,129.8	2.0	63,506.3	1.4
Wisconsin	16,544.5	0.5	62,520.7	2.0
CORN BELT				
Illinois	0.0	0.0	200,778.7	6.3
Indiana	8,910.8	0.4	98,903.8	4.8
Iowa	70,346.1	2.1	272,022.4	8.1
Missouri	0.0	0.0	205,628.1	5.2
Ohio	2,805.9	0.1	86,277.0	3.8
DELTA STATES				
Arkansas	356.3	0.0	54,540.1	1.9
Louisiana	0.0	0.0	32,183.9	1.3
Mississippi	0.0	0.0	82,249.7	3.1
NORTHERN PLAINS				
Kansas	89,181.4	1.8	112,905.1	2.3
Nebraska	41,821.2	0.9	139,011.2	3.0
North Dakota	85,969.2	2.1	120,580.9	2.9
South Dakota	45,261.1	1.0	117,392.1	2.6
SOUTHERN PLAINS				
Oklahoma	39,985.3	1.0	73,057.1	1.8
Texas	535,194.5	3.4	237,958.0	1.5

Appendix table 8.--Estimated average annual erosion (1982) on nonfederal rural land (except small built-up land) by state--continued

State	Wind erosion		Sheet and rill erosion	
	1,000 tons	tons/acre	1,000 tons	tons/acre
MOUNTAIN				
Arizona	142,878.6	3.6	27,513.8	0.7
Colorado	116,517.5	2.8	119,998.7	2.9
Idaho	19,436.3	1.0	38,210.4	2.0
Montana	144,309.6	2.2	70,513.0	1.1
Nevada	44,157.7	4.5	7,142.1	0.7
New Mexico	152,405.7	3.0	55,191.2	1.1
Utah	64,289.8	4.0	33,070.9	2.0
Wyoming	10,367.5	0.3	69,610.2	2.2
PACIFIC				
California	254,679.9	5.1	157,520.0	3.2
Oregon	11,918.3	0.4	67,809.3	2.4
Washington	18,201.5	0.6	53,810.6	1.9
OTHER				
Hawaii	0.0	0.0	14,876.6	4.1
Caribbean	0.0	0.0	23,361.5	12.1
Total	2,028,343.7	1.4	3,416,454.2	2.4

Source: 1982 National Resources Inventory.

Appendix table 9.--Estimated average annual erosion on all 1982 cropland, by state

State	Wind erosion		Sheet and rill erosion	
	1,000 tons	tons/acre	1,000 tons	tons/acre
NORTHEAST				
Connecticut	0.0	0.0	694.0	2.8
Delaware	940.5	1.8	1,042.0	2.0
Maine	0.0	0.0	1,988.6	2.1
Maryland	433.3	0.2	8,890.3	5.0
Massachusetts	0.0	0.0	620.8	2.1
New Hampshire	0.0	0.0	191.1	1.2
New Jersey	95.8	0.1	4,577.3	5.7
New York	0.0	0.0	17,413.3	3.0
Pennsylvania	0.0	0.0	31,171.1	5.3
Rhode Island	0.0	0.0	66.7	2.5
Vermont	0.0	0.0	831.1	1.3
APPALACHIA				
Kentucky	0.0	0.0	56,537.3	9.5
North Carolina	0.0	0.0	45,667.2	6.8
Tennessee	0.0	0.0	55,896.4	10.0
Virginia	633.5	0.2	21,008.8	6.2
West Virginia	0.0	0.0	2,810.0	2.6
SOUTHEAST				
Alabama	0.0	0.0	32,183.1	7.1
Florida	3,329.7	0.9	7,190.2	2.0
Georgia	0.0	0.0	41,713.7	6.4
South Carolina	0.0	0.0	12,931.6	3.6
LAKE STATES				
Michigan	15,309.9	1.6	20,982.5	2.2
Minnesota	90,053.9	3.9	57,706.3	2.5
Wisconsin	16,263.9	1.4	51,141.3	4.5
CORN BELT				
Illinois	0.0	0.0	172,432.0	7.0
Indiana	8,878.8	0.6	75,791.8	5.5
Iowa	70,206.8	2.7	247,791.8	9.4
Missouri	0.0	0.0	146,452.9	9.8
Ohio	2,795.5	0.2	46,587.3	3.7
DELTA STATES				
Arkansas	356.3	0.0	39,362.1	4.9
Louisiana	0.0	0.0	29,310.2	4.6
Mississippi	0.0	0.0	55,268.1	7.5
NORTHERN PLAINS				
Kansas	80,203.8	2.8	79,830.1	2.7
Nebraska	27,036.9	1.3	105,035.4	5.2
North Dakota	83,805.6	3.1	52,379.7	1.9
South Dakota	45,043.7	2.7	44,537.9	2.6
SOUTHERN PLAINS				
Oklahoma	38,672.4	3.3	25,034.1	2.2
Texas	437,970.3	13.1	87,413.8	2.6

Appendix table 9.--Estimated average annual erosion on all 1982 cropland, by state--continued

State	Wind erosion		Sheet and rill erosion	
	1,000 tons	tons/acre	1,000 tons	tons/acre
MOUNTAIN				
Arizona	3,941.2	3.3	582.7	0.5
Colorado	98,750.8	9.3	22,876.0	2.2
Idaho	18,438.0	2.9	32,132.0	5.0
Montana	143,337.1	8.3	26,614.1	1.6
Nevada	7,916.7	9.2	64.1	0.1
New Mexico	12,601.0	5.2	3,110.6	1.3
Utah	5,175.7	2.5	1,543.1	0.8
Wyoming	1,921.2	0.7	2,542.0	1.0
PACIFIC				
California	11,206.4	1.1	12,138.8	1.2
Oregon	7,365.9	1.7	17,299.2	4.0
Washington	16,468.8	2.1	37,194.6	4.8
OTHER				
Hawaii	0.0	0.0	2,115.0	6.4
Caribbean	0.0	0.0	4,694.7	11.5
Total	1,249,155.4	3.0	1,843,388.8	4.4

Source: 1982 National Resources Inventory.

Appendix table 10.--Nonfederal cropland eroding at rates greater than T

Farming region and state	Cropland (1,000 acres)	Acres eroding in excess of T			
		Sheet & rill		Wind	
		(1,000 acres)	Percent	(1,000 acres)	Percent
NORTHEAST					
Connecticut	244.7	55.2	23	0.0	*
Delaware	519.1	53.0	10	91.3	18
Maine	953.4	268.2	28	0.0	*
Maryland	1,794.4	589.4	33	13.3	*
Massachusetts	297.2	36.0	12	0.0	*
New Hampshire	157.8	9.3	6	0.0	*
New Jersey	809.4	384.3	48	0.0	*
New York	5,912.1	1,616.6	27	0.0	*
Pennsylvania	5,896.3	2,214.1	38	0.0	*
Rhode Island	27.2	8.4	31	0.0	*
Vermont	648.4	65.7	10	0.0	*
Region	17,259.9	5,300.2	31	104.6	*
LAKE STATES					
Michigan	9,443.0	1,204.4	13	920.9	10
Minnesota	23,024.0	3,023.2	13	7,078.8	31
Wisconsin	11,456.7	3,120.1	27	895.5	8
Region	43,923.9	7,347.7	17	8,895.1	20
CORN BELT					
Illinois	24,727.3	10,227.3	41	0.0	*
Indiana	13,781.2	4,687.4	34	556.8	4
Iowa	26,440.6	12,261.0	46	5,572.7	21
Missouri	14,998.3	7,223.7	48	0.0	*
Ohio	12,447.0	3,704.4	30	95.4	*
Region	92,394.8	38,104.0	41	6,224.9	7
NORTHERN PLAINS					
Kansas	29,008.2	4,475.6	15	4,990.6	17
Nebraska	20,276.6	4,620.7	23	1,461.6	7
North Dakota	27,039.1	2,579.1	10	6,261.2	23
South Dakota	16,947.1	2,391.6	14	2,911.3	17
Region	93,381.3	14,066.9	15	15,624.6	17
APPALACHIA					
Kentucky	5,934.2	2,412.7	41	0.0	*
North Carolina	6,694.8	2,476.4	37	0.0	*
Tennessee	5,592.1	2,806.9	50	0.0	*
Virginia	3,396.9	1,191.5	35	28.7	*
West Virginia	1,093.1	123.4	11	0.0	*
Region	22,711.0	9,010.8	40	28.7	*
SOUTHEAST					
Alabama	4,510.3	2,558.8	57	0.0	*
Florida	3,556.8	375.9	11	294.3	8
Georgia	6,568.4	3,072.7	47	0.0	*
South Carolina	3,578.7	699.1	20	0.0	*
Region	18,241.1	6,706.5	36	294.3	2
DELTA STATES					
Arkansas	8,101.5	3,276.1	40	0.0	*
Louisiana	6,408.9	2,171.0	34	0.0	*
Mississippi	7,415.2	3,009.9	41	0.0	*
Region	21,925.6	8,456.9	38	0.0	*

Appendix table 10.--Nonfederal cropland eroding at rates greater than T--continued

Farming region and state	Cropland (1,000 acres)	Acres eroding in excess of T			
		Sheet & rill		Wind	
		(1,000 acres)	Percent	(1,000 acres)	Percent
SOUTHERN PLAINS					
Oklahoma	11,568.0	1,395.5	12	2,399.7	21
Texas	33,319.5	4,898.5	15	15,518.7	47
Region	44,887.6	6,294.0	14	17,918.4	40
MOUNTAIN					
Arizona	1,206.3	0.0	*	187.1	16
Colorado	10,602.6	1,072.3	10	5,407.8	51
Idaho	6,390.1	2,454.2	38	1,221.6	19
Montana	17,196.8	1,714.3	10	8,330.5	48
Nevada	859.7	0.0	*	79.1	9
New Mexico	2,412.7	118.1	5	653.6	27
Utah	2,038.7	109.2	5	283.4	14
Wyoming	2,587.4	207.4	8	96.7	4
Region	43,294.4	5,675.5	13	16,259.9	38
PACIFIC					
California	10,517.6	503.7	5	423.8	4
Oregon	4,356.4	1,577.4	36	637.2	15
Washington	7,793.4	2,503.1	32	1,039.6	13
Region	22,667.4	4,548.2	20	2,100.6	9
OTHER					
Hawaii	333.2	102.0	31	0.0	*
Puerto Rico	408.3	177.5	44	0.0	*
TOTAL	421,402.4	105,826.5	25	67,451.4	16

* = less than 1 percent.
Source: 1982 National Resources Inventory.

Appendix table 11.--Average annual sheet and rill erosion on 1982 cropland

State	Capability class							
	I	II	III	IV	V	VI	VII	VIII
	(tons/acre)							
NORTHEAST								
Connecticut	2.1	3.5	3.0	1.8	-	1.9	1.0	-
Delaware	1.7	2.5	1.2	4.6	0.6	42.0	-	-
Maine	0.9	2.1	3.2	0.8	-	2.1	0.1	-
Maryland	2.1	3.5	4.8	9.7	1.4	19.0	13.8	-
Massachusetts	2.3	2.3	2.4	0.4	0.2	2.5	0.0	-
New Hampshire	1.4	0.9	1.7	0.9	0.1	0.5	0.8	-
New Jersey	3.7	5.2	8.0	6.8	0.3	3.4	1.5	0.3
New York	2.5	2.4	3.1	4.7	0.9	4.6	0.8	-
Pennsylvania	2.8	4.0	5.4	6.7	2.7	10.6	14.1	16.0
Rhode Island	3.2	2.5	1.1	2.9	0.2	0.0	-	-
Vermont	1.5	1.1	1.0	2.0	0.8	2.1	1.6	0
APPALACHIA								
Kentucky	2.5	5.7	9.1	21.1	2.7	35.7	29.3	-
North Carolina	2.8	6.3	6.2	10.9	1.4	21.1	7.4	-
Tennessee	3.0	6.8	10.2	15.4	3.7	27.4	33.9	-
Virginia	2.1	4.6	7.1	12.0	1.8	13.0	12.6	-
West Virginia	0.7	1.1	1.9	4.4	1.0	5.1	6.5	2.4
SOUTHEAST								
Alabama	4.3	6.3	8.3	7.7	2.6	12.7	19.7	-
Florida	4.6	4.4	1.7	1.4	0.6	2.1	1.1	-
Georgia	3.4	5.4	8.9	11.5	2.3	17.2	12.3	-
South Carolina	2.3	3.6	3.7	5.2	0.6	8.7	5.7	-
LAKE STATES								
Michigan	1.5	2.0	2.4	3.4	0.1	4.0	2.9	-
Minnesota	2.0	2.1	3.5	3.0	0.7	6.5	16.5	-
Wisconsin	2.4	3.3	4.9	7.6	1.8	6.6	10.3	3.5
CORN BELT								
Illinois	3.8	5.2	9.6	18.9	3.3	32.0	34.3	-
Indiana	3.6	4.2	6.8	11.9	1.5	37.4	28.9	0.8
Iowa	3.4	5.0	15.0	24.2	2.5	27.2	29.8	-
Missouri	3.0	5.5	12.7	17.7	5.1	27.2	32.6	-
Ohio	2.7	3.2	4.2	8.4	1.1	10.4	25.6	-
DELTA STATES								
Arkansas	5.7	5.3	4.4	5.1	4.7	16.2	7.6	-
Louisiana	5.4	5.3	4.2	4.2	3.7	3.7	4.3	-
Mississippi	4.8	5.5	6.6	9.2	3.6	32.6	38.9	-
NORTHERN PLAINS								
Kansas	1.5	2.1	3.3	4.7	2.3	7.4	15.2	-
Nebraska	1.7	2.4	6.8	9.9	0.5	11.8	8.9	0.0
North Dakota	-	1.5	2.2	2.6	0.6	4.9	3.6	8.3
South Dakota	2.0	2.1	2.7	4.2	0.8	5.5	4.5	-
SOUTHERN PLAINS								
Oklahoma	1.4	1.9	2.1	3.0	1.1	4.6	3.5	-
Texas	1.8	2.5	2.7	3.2	2.1	3.8	2.1	-

Appendix table 11.--Average annual sheet and rill erosion on 1982 cropland--continued

State	Capability class							
	I	II	III	IV	V	VI	VII	VIII
	(tons/acre)							
MOUNTAIN								
Arizona	0.5	0.4	0.5	0.1	-	1.4	1.0	-
Colorado	1.2	1.8	1.6	2.4	0.0	3.9	4.2	-
Idaho	1.9	2.3	5.7	7.4	0.4	8.1	8.7	2.6
Montana	-	0.3	1.4	1.9	0.1	2.2	2.6	-
Nevada	0.0	0.1	0.0	0.1	0.0	0.1	0.1	-
New Mexico	0.6	1.2	1.4	1.2	0.3	1.7	1.5	-
Utah	0.5	0.4	0.7	1.1	0.1	1.5	0.9	0.1
Wyoming	1.4	0.5	1.0	1.0	0.1	1.6	1.1	-
PACIFIC								
California	0.3	0.3	0.5	2.7	0.1	12.5	14.3	1.9
Oregon	1.5	2.7	5.6	3.0	0.1	3.6	2.0	-
Washington	0.7	2.1	4.3	6.6	0.0	9.5	4.8	0.4
OTHER								
Caribbean	1.0	1.6	3.0	2.6	-	10.9	24.5	59.2
Hawaii	1.0	2.3	4.0	8.8	-	14.9	25.4	-

Source: 1982 National Resources Inventory.

Appendix table 12.--1982 cropland, by EI category and state

Farming region and state	EI <5	5-8	8-15	>15	Total
	(1,000 acres)				
NORTHEAST					
Connecticut	137.7	37.1	27.4	42.5	244.7
Delaware	419.1	77.4	12.3	10.3	519.1
Maine	520.2	184.4	160.1	88.7	953.4
Maryland	932.6	220.3	268.8	372.7	1,794.4
Massachusetts	167.7	28.3	36.4	64.8	297.2
New Hampshire	104.2	18.5	14.3	20.8	157.8
New Jersey	484.1	110.9	90.1	124.3	809.4
New York	3,082.5	835.3	898.6	1,095.7	5,912.1
Pennsylvania	1,234.4	881.1	1,338.2	2,442.6	5,896.3
Rhode Island	13.8	9.5	2.5	1.4	27.2
Vermont	358.3	94.0	102.3	93.8	648.4
Region	7,454.6	2,496.8	2,951.0	4,357.6	17,251.0
APPALACHIA					
Kentucky	1,980.1	813.3	1,033.0	2,107.8	5,934.2
North Carolina	4,202.8	774.8	812.5	904.7	6,694.8
Tennessee	2,319.1	759.9	1,183.4	1,329.7	5,592.1
Virginia	1,248.0	536.0	581.7	1,031.2	3,396.9
West Virginia	413.3	73.9	134.3	471.6	1,093.1
Region	10,163.3	2,957.9	3,744.9	5,845.0	22,711.1
SOUTHEAST					
Alabama	2,150.1	953.4	895.8	511.0	4,510.3
Florida	3,170.0	184.3	139.2	63.3	3,556.8
Georgia	4,710.3	775.0	610.4	472.7	6,568.4
South Carolina	2,860.6	248.4	298.0	171.7	3,578.7
Region	12,891.0	1,961.1	1,943.4	1,218.7	18,214.2
LAKE STATES					
Michigan	8,238.9	586.4	424.5	193.3	9,443.1
Minnesota	19,360.1	2,027.9	1,113.1	523.0	23,024.1
Wisconsin	6,592.0	1,443.0	1,397.5	2,024.3	11,456.8
Region	34,191.0	4,057.3	2,935.1	2,720.6	43,924.0
CORN BELT					
Illinois	18,154.9	2,463.7	2,175.7	1,933.1	24,727.4
Indiana	10,263.0	1,315.1	1,031.6	1,171.6	13,781.3
Iowa	15,666.0	2,559.9	3,221.3	4,993.5	26,440.7
Missouri	7,018.9	1,680.6	2,527.4	3,771.5	14,998.4
Ohio	8,668.5	1,430.9	1,037.8	1,309.9	12,447.1
Region	59,791.3	9,450.2	9,993.8	13,179.6	92,394.9
DELTA STATES					
Arkansas	6,565.8	811.1	475.5	249.1	8,101.5
Louisiana	5,694.4	426.4	186.6	101.5	6,408.9
Mississippi	4,849.2	780.0	644.7	1,141.4	7,415.3
Region	17,109.4	2,017.5	1,306.8	1,492.0	21,925.7
NORTHERN PLAINS					
Kansas	6,101.6	12,422.1	7,789.7	2,804.9	29,118.3
Nebraska	10,051.0	3,593.5	4,167.0	2,465.2	20,276.7
North Dakota	20,481.4	4,286.3	1,958.0	313.5	27,039.2
South Dakota	12,387.5	2,856.3	1,359.7	343.7	16,947.2
Region	49,021.5	23,158.2	15,274.4	5,927.3	93,381.4

Appendix table 12.--1982 cropland, by EI category and state--continued

Farming region and state	EI <5	EI 5-8	EI 8-15	EI >15	Total
	(1,000 acres)				
SOUTHERN PLAINS					
Oklahoma	4,501.0	2,367.9	3,120.2	1,579.0	11,568.1
Texas	9,939.3	9,477.3	8,941.7	4,961.3	33,319.6
Region	14,440.3	11,845.2	12,061.9	6,540.3	44,887.7
MOUNTAIN					
Arizona	46.0	56.8	354.4	749.1	1,206.3
Colorado	1,517.0	2,960.9	4,053.0	2,071.8	10,602.7
Idaho	2,514.1	1,226.5	1,843.5	806.0	6,390.1
Montana	3,139.3	4,499.5	7,367.6	2,190.5	17,196.9
Nevada	764.7	19.1	30.5	45.4	859.7
New Mexico	244.5	575.2	873.3	719.7	2,412.7
Utah	1,316.2	107.5	510.5	104.5	2,038.7
Wyoming	2,276.7	136.2	115.1	59.4	2,587.4
Region	11,818.5	9,581.7	15,147.9	6,746.4	43,294.5
PACIFIC					
California	9,117.3	644.0	320.3	436.1	10,517.7
Oregon	2,856.4	531.0	759.3	209.7	4,356.4
Washington	3,906.2	1,491.1	1,720.2	675.9	7,793.4
Region	15,879.9	2,666.1	2,799.8	1,321.7	22,667.5
OTHER					
Hawaii	143.3	59.3	71.8	58.8	333.2
Caribbean	121.6	29.9	16.2	240.6	408.3
TOTAL	233,005.7	70,481.2	68,247.0	49,668.6	421,402.5

The erodibility index (EI) is calculated by multiplying together the erosion equation factors that represent soil, topographic, and climatic conditions and dividing the product by the soil loss tolerance assigned to the soil.

"EI" <2 means the indexes for both sheet and rill erosion and wind erosion are less than 2. For all other classes, classification is based on the higher of the two indexes.

Source: 1982 National Resources Inventory.

Appendix table 13.--Nonfederal cropland: susceptibility to damage resulting from sheet and rill erosion compared with susceptibility to damage resulting from wind erosion

	CI/T					
	<2	2-5	5-10	10-15	>15	Total
	(million acres)					
RKLS/T						
< 2	93.9	47.0	41.0	15.3	10.3	207.5
2-5	77.2	14.9	11.7	3.6	3.0	110.4
5-10	39.4	4.6	2.8	1.3	1.2	49.3
10-15	17.0	1.0	0.7	0.3	0.4	19.4
>15	31.8	1.6	0.5	0.2	0.4	34.5
Total	259.3	69.1	56.7	20.7	15.3	421.1

Source: 1982 National Resources Inventory.

Appendix table 14.--Acreage of cropland in each land capability class and subclass, rated according to susceptibility to damage resulting from sheet and rill erosion and from wind erosion

Class and subclass	<2	2-5		5-10		10-15		>15		Total
		Water	Wind	Water	Wind	Water	Wind	Water	Wind	
	(1,000 acres)									
I	13,571.2	7,509.9	4,198.8	530.8	2,746.2	42.9	919.5	27.4	672.4	30,219.1
IIc	2,087.6	215.1	9,430.5	30.0	5,482.9	3.0	441.9	1.9	65.6	17,758.5
IIe	7,443.3	26,212.2	16,232.2	19,227.3	9,348.7	5,884.1	2,497.5	3,640.7	877.1	91,363.1
IIs	4,852.4	3,433.3	2,882.5	789.2	3,918.1	66.2	912.6	19.4	313.3	17,187.0
IIw	33,783.6	18,195.6	7,170.7	3,485.1	1,257.9	432.5	339.0	253.7	33.7	64,951.8
IIIc	403.0	174.6	480.8	58.5	2,482.9	10.6	1,488.9	0.9	64.4	5,164.6
IIIe	3,816.5	7,162.8	5,455.9	13,404.5	18,609.9	8,093.8	6,845.9	14,620.1	4,710.9	82,720.3
IIIs	4,473.6	1,512.8	2,982.8	520.1	1,893.1	168.3	389.5	91.5	466.4	12,498.1
IIIw	13,868.1	12,416.4	3,108.3	1,854.2	994.0	355.2	335.0	262.6	97.9	33,291.7
IVc	137.6	31.5	82.4	15.6	186.0	2.6	9.8	1.5	3.4	470.4
IVe	1,632.3	1,368.9	991.0	3,297.3	4,279.3	2,678.7	3,896.2	9,179.7	5,156.1	32,479.2
IVs	2,013.5	780.1	1,535.5	472.8	796.3	182.8	402.3	297.4	341.2	6,821.9
IVw	2,754.8	1,866.1	1,194.2	263.8	601.9	71.0	220.7	148.6	70.2	7,191.3
V	1,058.1	582.4	324.4	81.5	202.7	5.6	61.4	19.6	20.6	2,356.7
VIc	41.7	16.6	26.4	5.3	31.9	0.0	53.6	0.0	18.2	193.7
VIe	384.5	362.0	225.2	673.1	822.7	634.3	1,039.7	4,110.8	1,676.3	9,928.6
VIs	468.4	247.7	206.9	283.3	410.2	146.1	262.0	373.5.	403.2	2,801.3
VIw	630.0	115.8	132.3	16.1	88.4	1.9	124.5	1.5	70.5	1,181.0
VIIc	24.6	0.0	0.3	0.0	3.3	0.0	21.5	0.0	14.6	64.3
VIIe	54.8	32.0	3.1	50.5	17.2	58.3	40.7	919.6	127.4	1,303.6
VIIs	137.0	136.2	67.6	122.5	65.3	52.5	75.6	322.5	144.0	1,123.2
VIIw	178.7	14.9	56.8	1.3	18.3	0.3	12.6	0.0	15.7	298.6
VIII	8.9	1.3	4.3	1.1	3.6	2.6	0.1	8.5	4.1	34.5
TOTAL	93,824.2	82,388.2	56,793.3	45,183.6	54,260.8	18,893.3	20,390.5	34,301.4	15,367.2	421,402.5

Rating of susceptibility to damage is based on the higher of the two ratings. For example, on the land assigned to the second group (index of 2 to 5), neither the index for sheet and rill erosion nor that for wind erosion is greater than 5. If the index for sheet and rill erosion (RKLS) is greater than the index for wind erosion (CI), the acreage is in the column headed water; if the CI index is greater, the acreage is included in the column headed wind.

Source: 1982 National Resources Inventory.

Appendix table 15.--Susceptibility to damage resulting from sheet and rill erosion on cropland, by state

State	RKLS/T <2	2-5	5-10	10-15	>15	Total
	(1,000 acres)					
NORTHEAST						
Connecticut	47	90	51	17	40	245
Delaware	340	127	35	7	10	519
Maine	221	299	255	90	88	953
Maryland	352	579	329	165	370	1,794
Massachusetts	76	91	46	20	64	297
New Hampshire	58	46	23	10	21	158
New Jersey	182	304	150	51	123	809
New York	1,387	1,679	1,219	549	1,079	5,912
Pennsylvania	283	928	1,413	853	2,420	5,896
Rhode Island	3	11	10	2	1	27
Vermont	166	191	149	50	92	648
APPALACHIA						
Kentucky	734	1,235	1,213	648	2,105	5,934
North Carolina	2,519	1,668	1,124	484	900	6,695
Tennessee	545	1,763	1,195	769	1,320	5,592
Virginia	437	793	770	378	1,019	3,379
West Virginia	220	191	134	79	470	1,093
SOUTHEAST						
Alabama	395	1,738	1,396	474	507	4,510
Florida	2,446	733	244	73	62	3,557
Georgia	1,702	3,003	1,046	351	468	6,568
South Carolina	2,124	729	385	168	172	3,579
LAKE STATES						
Michigan	6,433	1,803	809	211	187	9,443
Minnesota	16,870	3,667	1,513	462	513	23,084
Wisconsin	3,492	3,209	1,875	868	2,013	11,457
CORN BELT						
Illinois	10,322	7,807	3,406	1,270	1,923	24,727
Indiana	6,164	4,073	1,790	594	1,160	13,781
Iowa	8,796	6,893	3,730	2,849	4,973	26,441
Missouri	4,274	2,722	2,649	1,610	3,744	14,998
Ohio	5,245	3,401	1,909	583	1,309	12,447
DELTA STATES						
Arkansas	1,580	4,959	1,083	233	247	8,102
Louisiana	1,440	4,243	519	103	99	6,409
Mississippi	1,352	3,486	1,050	388	1,138	7,415
NORTHERN PLAINS						
Kansas	12,590	9,761	4,638	1,182	947	29,118
Nebraska	10,645	4,339	2,104	1,219	1,971	20,277
North Dakota	21,675	3,917	1,132	162	153	27,039
South Dakota	11,258	3,863	1,350	272	204	16,947
SOUTHERN PLAINS						
Oklahoma	5,845	4,100	1,857	348	218	11,568
Texas	21,941	7,986	2,518	528	346	33,320

Appendix table 15.--Susceptibility to damage resulting from sheet and rill erosion on cropland, by state--continued

State	RKLS/T					Total
	<2	2-5	5-10	10-15	>15	
	(1,000 acres)					
MOUNTAIN						
Arizona	1,203	4	0	0	0	1,206
Colorado	8,423	1,699	376	57	48	10,603
Idaho	2,640	1,626	1,418	375	331	6,390
Montana	13,156	2,809	906	191	135	17,197
Nevada	858	1	1	0	0	860
New Mexico	1,194	152	56	9	3	2,413
Utah	1,517	383	104	17	17	2,039
Wyoming	2,148	300	108	14	18	2,587
PACIFIC						
California	9,554	382	184	83	314	10,518
Oregon	2,125	1,095	645	311	181	4,356
Washington	3,443	1,611	1,437	824	479	7,793
OTHER						
Hawaii	62	82	84	47	59	333
Caribbean	48	73	37	9	241	408
TOTAL	210,530	106,644	50,475	20,057	34,302	421,441

Source: 1982 National Resources Inventory.

Appendix table 16.--Susceptibility to damage resulting from wind erosion on cropland, by state

State	CI/T <2	2-5	5-10	10-15	>15	Total
	------------------------------(1,000 acres)-------------------------					
NORTHEAST						
Connecticut	244.7	0.0	0.0	0.0	0.0	244.7
Delaware	257.3	212.8	47.8	1.2	0.0	519.1
Maine	9,53.4	0.0	0.0	0.0	0.0	9,53.4
Maryland	1,674.1	116.0	4.3	0.0	0.0	1,794.4
Massachusetts	297.2	0.0	0.0	0.0	0.0	297.2
New Hampshire	157.8	0.0	0.0	0.0	0.0	157.8
New Jersey	738.6	66.5	4.3	0.0	0.0	809.4
New York	5,912.1	0.0	0.0	0.0	0.0	5,912.1
Pennsylvania	5,896.3	0.0	0.0	0.0	0.0	5,896.3
Rhode Island	27.2	0.0	0.0	0.0	0.0	27.2
Vermont	648.4	0.0	0.0	0.0	0.0	648.4
APPALACHIA						
Kentucky	5,934.2	0.0	0.0	0.0	0.0	5,934.2
North Carolina	6,694.8	0.0	0.0	0.0	0.0	6,694.8
Tennessee	5,592.1	0.0	0.0	0.0	0.0	5,592.1
Virginia	3,322.5	71.5	1.5	0.0	1.5	3,396.9
West Virginia	1,093.1	0.0	0.0	0.0	0.0	1,093.1
SOUTHEAST						
Alabama	4,510.3	0.0	0.0	0.0	0.0	4,510.3
Florida	2,727.0	814.2	14.3	0.0	1.3	3,556.8
Georgia	6,568.4	0.0	0.0	0.0	0.0	6,568.4
South Carolina	3,578.7	0.0	0.0	0.0	0.0	3,578.7
LAKE STATES						
Michigan	8,714.1	715.1	12.7	1.2	0.0	9,443.1
Minnesota	12,966.1	8,794.3	1,033.1	230.2	0.4	23,024.1
Wisconsin	10,278.4	1,037.2	133.8	0.0	7.4	11,456.8
CORN BELT						
Illinois	24,727.4	0.0	0.0	0.0	0.0	24,727.4
Indiana	13,447.9	328.1	5.3	0.0	0.0	13,781.3
Iowa	22,269.5	4,099.9	26.6	44.7	0.0	26,440.7
Missouri	14,998.4	0.0	0.0	0.0	0.0	14,998.4
Ohio	12,215.3	230.8	1.0	0.0	0.0	12,447.1
DELTA STATES						
Arkansas	8,101.5	0.0	0.0	0.0	0.0	8,101.5
Louisiana	6,408.9	0.0	0.0	0.0	0.0	6,408.9
Mississippi	7,415.3	0.0	0.0	0.0	0.0	7,415.3
NORTHERN PLAINS						
Kansas	7,534.2	3,869.8	12,612.3	3,217.9	1,884.1	29,118.3
Nebraska	6,817.0	7,908.2	4,143.5	923.7	484.3	20,276.7
North Dakota	2,639.2	18,558.1	5,303.7	305.8	232.4	27,039.2
South Dakota	2,818.9	10,636.1	3,141.4	173.0	177.8	16,947.2
SOUTHERN PLAINS						
Oklahoma	2,494.1	3,497.9	2,263.4	1,849.9	1,462.8	11,568.1
Texas	8,727.8	3,609.0	10,435.0	5,890.1	4,657.7	33,319.6

Appendix table 16.--Susceptibility to damage resulting from wind erosion on cropland, by state--continued

State	CI/T <2	2-5	5-10	10-15	>15	Total
	---------------------------	(1,000 acres)	---------------------------			
MOUNTAIN						
Arizona	9.3	36.7	251.1	160.1	749.1	1,206.3
Colorado	1,014.6	600.9	4,215.5	2,734.2	2,037.5	10,602.7
Idaho	3,799.9	237.3	1,513.1	353.1	486.6	6,390.1
Montana	3,076.3	323.9	7,979.2	3,682.2	2,134.8	17,196.9
Nevada	718.7	46.5	32.2	16.9	45.4	859.7
New Mexico	33.4	214.4	886.9	558.8	719.2	2,412.7
Utah	1,445.5	2.5	360.3	143.3	87.1	2,038.7
Wyoming	2,319.8	70.9	110.2	44.1	42.4	2,587.4
PACIFIC						
California	9,184.5	511.4	671.5	28.5	121.8	10,517.7
Oregon	2,493.2	1,008.1	711.4	114.5	29.2	4,356.4
Washington	5,020.3	1,522.1	796.9	257.7	196.4	7,793.4
OTHER						
Hawaii	333.2	0.0	0.0	0.0	0.0	333.2
Caribbean	408.3	0.0	0.0	0.0	0.0	408.3
TOTAL	259,259.2	69,140.2	56,712.2	20,731.7	15,559.2	421,402.5

Source: 1982 National Resources Inventory.

Appendix table 17a.--Annual sheet and rill erosion on cropland, and the amount of erosion in excess of T, by erosion interval, 1982

Erosion interval (tons/acre)	Total acres (millions)	Cumulative percentage of acreage	Sheet & rill erosion (million tons)	Cumulative percentage of erosion	Erosion in excess of T (million tons)	Cumulative percentage of erosion in excess of T
>T+20	11.6	2.7	502.1	27.2	454.1	50.5
T+19 to T+20	0.8	2.9	19.0	28.3	15.7	52.2
T+18 to T+19	0.9	3.1	19.6	29.3	16.1	54.0
T+17 to T+18	1.0	3.4	21.2	30.5	17.1	55.9
T+16 to T+17	1.1	3.6	22.6	31.7	18.1	57.9
T+15 to T+16	1.2	3.9	23.8	33.0	18.7	60.0
T+14 to T+15	1.4	4.3	26.1	34.4	20.3	62.3
T+13 to T+14	1.5	4.6	26.6	35.9	20.4	64.5
T+12 to T+13	1.8	5.0	29.4	37.4	22.1	67.0
T+11 to T+12	2.0	5.5	30.8	39.1	22.7	69.5
T+10 to T+11	2.3	6.1	34.2	41.0	24.6	72.2
T+9 to T+10	2.4	6.6	32.8	42.8	22.8	74.8
T+8 to T+9	3.1	7.4	39.2	44.9	26.4	77.7
T+7 to T+8	3.5	8.2	40.8	47.1	26.3	80.6
T+6 to T+7	4.3	9.2	45.6	49.6	27.9	83.7
T+5 to T+6	5.2	10.5	49.8	52.3	28.5	86.9
T+4 to T+5	6.5	12.0	56.2	55.3	29.2	90.2
T+3 to T+4	8.6	14.0	65.0	58.8	29.9	93.5
T+2 to T+3	11.1	16.7	73.1	62.8	27.4	96.5
T+1 to T+2	14.8	20.2	83.1	67.3	21.5	98.9
T to T+1	21.2	25.2	96.9	72.6	9.8	100.0
<T	315.1	100.0	505.6	100.0	0.0	100.0
Total	421.4		1,843.4		899.4	

Source: 1982 National Resources Inventory.

Appendix table 17b.--Annual wind erosion on cropland, and the amount of erosion in excess of T, by erosion interval, 1982

Erosion interval (tons/acre)	Total acres (millions)	Cumulative percentage of acreage	Wind erosion (million tons)	Cumulative percentage of erosion	Erosion in excess of T (million tons)	Cumulative percentage of erosion in excess of T
>T+20	9.1	2.2	456.5	36.5	414.0	56.9
T+19 to T+20	0.6	2.3	14.7	37.7	11.9	58.6
T+18 to T+19	0.6	2.4	12.9	38.8	10.4	60.0
T+17 to T+18	0.7	2.6	15.1	40.0	11.9	61.6
T+16 to T+17	0.9	2.8	18.4	41.4	14.3	63.6
T+15 to T+16	0.9	3.0	17.6	42.8	13.5	65.5
T+14 to T+15	1.0	3.2	18.4	44.3	13.9	67.4
T+13 to T+14	1.1	3.5	19.4	45.9	14.5	69.4
T+12 to T+13	1.4	3.8	23.1	47.7	17.0	71.7
T+11 to T+12	1.4	4.2	22.9	49.5	16.4	74.0
T+10 to T+11	1.6	4.5	24.8	51.5	17.3	76.3
T+9 to T+10	1.7	5.0	24.4	53.5	16.5	78.6
T+8 to T+9	2.0	5.4	26.2	55.6	16.9	80.9
T+7 to T+8	3.2	6.2	39.2	58.7	24.2	84.3
T+6 to T+7	3.1	6.9	34.7	61.5	20.4	87.1
T+5 to T+6	4.1	7.9	41.1	64.8	22.3	90.1
T+4 to T+5	4.5	9.0	40.3	68.0	19.9	92.9
T+3 to T+4	5.4	10.2	43.5	71.5	18.7	95.5
T+2 to T+3	6.4	11.8	45.5	75.1	15.9	97.6
T+1 to T+2	8.4	13.8	50.8	79.2	12.5	99.4
T to T+1	9.8	16.1	48.0	83.1	4.6	100.0
<T	353.6	100.0	211.6	100.0	0.0	100.0
Total	421.4		1,249.2		727.1	

Source: 1982 National Resources Inventory.

Appendix table 18.--Annual sheet and rill erosion on pastureland, and the amount of erosion in excess of T, by erosion interval, 1982

Erosion interval (tons/acre)	Total acres (millions)	Cumulative percentage of acreage	Sheet & rill erosion (million tons)	Cumulative percentage of erosion	Erosion in excess of T (million tons)	Cumulative percentage of erosion in excess of T
>T+20	1.0	0.7	41.9	23.3	38.7	46.3
T+19 to T+20	0.1	0.8	1.7	24.2	1.4	48.0
T+18 to T+19	0.1	0.8	1.4	25.0	1.2	49.4
T+17 to T+18	0.1	0.9	2.1	26.2	1.8	51.5
T+16 to T+17	0.1	1.0	1.8	27.2	1.5	53.3
T+15 to T+16	0.1	1.0	1.9	28.2	1.5	55.2
T+14 to T+15	0.1	1.1	1.7	29.2	1.3	56.8
T+13 to T+14	0.2	1.2	2.6	30.6	2.0	59.2
T+12 to T+13	0.2	1.4	2.5	31.9	2.0	61.6
T+11 to T+12	0.2	1.5	2.4	33.3	1.8	63.8
T+10 to T+11	0.2	1.6	3.0	34.9	2.2	66.4
T+9 to T+10	0.3	1.9	4.4	37.4	3.2	70.3
T+8 to T+9	0.3	2.1	3.8	39.5	2.7	73.5
T+7 to T+8	0.4	2.4	4.5	42.0	3.1	77.2
T+6 to T+7	0.5	2.8	4.6	44.5	3.0	80.7
T+5 to T+6	0.6	3.2	5.0	47.3	3.2	84.5
T+4 to T+5	0.7	3.7	5.4	50.3	3.1	88.2
T+3 to T+4	0.9	4.4	6.2	53.7	3.2	92.1
T+2 to T+3	1.2	5.3	6.9	57.5	3.0	95.6
T+1 to T+2	1.7	6.6	7.6	61.8	2.4	98.5
T to T+1	2.7	8.6	9.1	66.9	1.2	100.0
<T	121.8	100.0	59.7	100.0	0.0	100.0
Total	133.3		180.1		83.7	

Source: 1982 National Resources Inventory.

Appendix table 19.--Annual sheet and rill erosion on forest land, and the amount of erosion in excess of T, by erosion interval, 1982

Erosion interval (tons/acre)	Total acres (millions)	Cumulative percentage of acreage	Sheet & rill erosion (million tons)	Cumulative percentage of erosion	Erosion in excess of T (million tons)	Cumulative percentage of erosion in excess of T
>T+20	2.8	0.7	139.0	37.6	131.8	61.0
T+19 to T+20	0.2	0.8	3.5	38.5	3.1	62.4
T+18 to T+19	0.2	0.8	3.2	39.4	2.8	63.7
T+17 to T+18	0.2	0.9	5.0	40.7	4.2	65.7
T+16 to T+17	0.2	0.9	4.1	41.8	3.5	67.3
T+15 to T+16	0.3	1.0	4.6	43.1	3.9	69.2
T+14 to T+15	0.3	1.1	5.4	44.5	4.6	71.3
T+13 to T+14	0.3	1.1	4.3	45.7	3.7	73.0
T+12 to T+13	0.3	1.2	4.4	46.9	3.7	74.7
T+11 to T+12	0.3	1.3	4.5	48.1	3.7	76.4
T+10 to T+11	0.4	1.4	5.2	49.5	4.2	78.3
T+9 to T+10	0.4	1.5	4.6	50.7	3.6	80.0
T+8 to T+9	0.7	1.7	7.4	52.7	5.7	82.6
T+7 to T+8	0.7	1.8	6.4	54.5	4.9	84.9
T+6 to T+7	0.7	2.0	6.4	56.2	4.6	87.0
T+5 to T+6	0.9	2.2	7.0	58.1	4.8	89.2
T+4 to T+5	1.1	2.5	7.8	60.2	5.0	91.5
T+3 to T+4	1.6	2.9	9.6	62.8	5.5	94.1
T+2 to T+3	2.2	3.5	10.5	65.6	5.4	96.6
T+1 to T+2	3.2	4.3	12.1	68.9	4.6	98.7
T to T+1	8.8	6.5	16.3	73.3	2.8	100.0
<T	368.1	100.0	98.8	100.0	0.0	100.0
Total	393.7		370.0		216.1	

Source: 1982 National Resources Inventory.

Appendix table 20.--Nonfederal pastureland eroding at rates greater than T

Farming region and state	Pastureland (1,000 acres)	Acres eroding in excess of T			
		Sheet & rill		Wind	
		(1,000 acres)	Percent	(1,000 acres)	Percent
NORTHEAST					
Connecticut	114.0	0.0	*	0.0	*
Delaware	35.2	1.3	4	0.0	*
Maine	569.0	8.5	2	0.0	*
Maryland	534.1	42.1	8	0.0	*
Massachusetts	201.6	1.2	*	0.0	*
New Hampshire	124.5	6.7	5	0.0	*
New Jersey	239.6	8.1	3	0.0	*
New York	3,871.8	96.4	3	0.0	*
Pennsylvania	2,592.6	224.1	9	0.0	*
Rhode Island	35.9	0.0	*	0.0	*
Vermont	500.7	9.7	2	0.0	*
Region	8,818.9	398.1	5	0.0	*
APPALACHIA					
Kentucky	5,879.8	1,055.7	18	0.0	*
North Carolina	1,980.2	202.8	10	0.0	*
Tennessee	5,355.6	462.7	9	0.0	*
Virginia	3,392.0	724.9	21	0.0	*
West Virginia	1,869.1	569.9	31	0.0	*
Region	18,476.6	3,016.0	16	0.0	*
SOUTHEAST					
Alabama	3,816.6	171.4	5	0.0	*
Florida	4,273.2	0.0	*	0.0	*
Georgia	2,976.6	95.1	3	0.0	*
South Carolina	1,208.0	10.8	*	0.0	*
Region	12,274.3	277.3	2	0.0	*
LAKE STATES					
Michigan	2,911.0	33.2	1	8.8	*
Minnesota	3,589.8	65.0	2	0.0	*
Wisconsin	3,394.2	186.6	6	0.0	*
Region	9,894.9	284.8	3	8.8	*
CORN BELT					
Illinois	3,157.3	469.0	15	0.0	*
Indiana	2,211.9	347.2	16	0.0	*
Iowa	4,536.1	394.2	9	1.5	*
Missouri	12,572.9	2,273.6	18	0.0	*
Ohio	2,713.9	556.3	21	0.0	*
Region	25,192.1	4,040.3	16	1.5	*
DELTA STATES					
Arkansas	5,793.8	266.4	5	0.0	*
Louisiana	2,368.5	14.9	*	0.0	*
Mississippi	3,975.2	438.3	11	0.0	*
Region	12,137.4	719.6	6	0.0	*
NORTHERN PLAINS					
Kansas	2,240.9	202.5	9	0.0	*
Nebraska	2,125.3	199.0	9	5.0	*
North Dakota	1,271.9	21.9	2	1.3	*
South Dakota	2,703.0	18.1	*	0.0	*
Region	8,341.1	441.5	5	6.3	*

Appendix table 20.--Nonfederal pastureland eroding at rates greater than T--continued

Farming region and state	Pastureland (1,000 acres)	Acres eroding in excess of T			
		Sheet & rill		Wind	
		(1,000 acres)	Percent	(1,000 acres)	Percent
SOUTHERN PLAINS					
Oklahoma	7,137.9	493.9	7	0.0	*
Texas	17,042.7	633.3	4	33.0	*
Region	24,180.6	1,127.2	5	33.0	*
MOUNTAIN					
Arizona	79.3	0.0	*	0.4	*
Colorado	1,259.7	23.4	2	46.1	4
Idaho	1,274.2	40.1	3	2.5	*
Montana	3,036.0	36.3	1	5.5	*
Nevada	304.4	0.0	*	0.9	*
New Mexico	163.3	1.0	*	3.7	2
Utah	490.3	0.0	*	25.8	5
Wyoming	754.8	22.1	3	0.7	*
Region	7,360.0	122.9	2	85.6	1
PACIFIC					
California	1,392.5	36.2	3	12.2	*
Oregon	1,965.9	147.4	8	18.6	*
Washington	1,344.6	20.7	2	3.2	*
Region	4,703.0	204.3	4	34.0	*
OTHER					
Hawaii	974.0	255.0	26	0.0	*
Puerto Rico	955.0	466.4	49	0.0	*
TOTAL	133,310.5	11,353.3	9	169.2	*

* = less than 1 percent.
Source: 1982 National Resources Inventory.

Appendix table 21.--Nonfederal forest land eroding at rates greater than T

Farming region and state	Forest land (1,000 acres)	Acres eroding in excess of T: Sheet & rill (1,000 acres)	Sheet & rill Percent	Wind (1,000 acres)	Wind Percent
NORTHEAST					
Connecticut	1,828.3	4.6	*	0.0	*
Delaware	347.6	0.7	*	0.0	*
Maine	16,770.2	100.0	*	0.0	*
Maryland	2,425.3	17.6	*	0.0	*
Massachusetts	2,970.1	6.5	*	0.0	*
New Hampshire	4,085.1	18.2	*	0.0	*
New Jersey	1,848.4	60.6	3	0.0	*
New York	16,516.8	65.8	*	0.0	*
Pennsylvania	15,300.2	435.5	3	0.0	*
Rhode Island	405.5	0.4	*	0.0	*
Vermont	4,086.5	30.3	*	0.0	*
Region	66,584.2	740.2	1	0.0	*
APPALACHIA					
Kentucky	10,158.1	936.1	9	0.0	*
North Carolina	16,728.4	167.9	1	0.0	*
Tennessee	11,529.0	325.8	3	0.0	*
Virginia	13,625.2	784.1	6	0.0	*
West Virginia	10,422.4	1,080.3	10	0.0	*
Region	62,463.5	3,294.2	5	0.0	*
SOUTHEAST					
Alabama	20,633.2	504.2	2	0.0	*
Florida	12,430.0	15.2	*	0.0	*
Georgia	21,883.5	232.3	1	0.0	*
South Carolina	11,025.4	98.1	*	0.0	*
Region	65,972.4	849.8	1	0.0	*
LAKE STATES					
Michigan	15,359.6	97.7	*	1.6	*
Minnesota	13,956.2	139.3	1	0.0	*
Wisconsin	13,392.7	243.5	2	0.0	*
Region	42,708.7	480.5	1	1.6	*
CORN BELT					
Illinois	3,429.4	395.0	12	0.0	*
Indiana	3,639.9	130.1	4	0.0	*
Iowa	1,756.2	232.8	13	0.0	*
Missouri	10,985.5	1,511.5	14	0.0	*
Ohio	6,380.2	773.4	12	0.0	*
Region	26,191.2	3,042.8	12	0.0	*
NORTHERN PLAINS					
Kansas	626.2	80.0	13	0.0	*
Nebraska	732.1	123.4	17	0.0	*
North Dakota	438.2	2.6	*	0.0	*
South Dakota	561.6	48.8	9	0.0	*
Region	2,358.1	254.8	11	0.0	*
DELTA STATES					
Arkansas	14,339.7	199.0	1	0.0	*
Louisiana	12,894.9	56.3	*	0.0	*
Mississippi	15,242.6	605.1	4	0.0	*
Region	42,477.4	860.4	2	0.0	*

Appendix table 21.--Nonfederal forest land eroding at rates greater than T--continued

Farming region and state	Forest land (1,000 acres)	Acres eroding in excess of T			
		Sheet & rill		Wind	
		(1,000 acres)	Percent	(1,000 acres)	Percent
SOUTHERN PLAINS					
Oklahoma	6,538.7	708.1	11	0.0	*
Texas	9,323.6	416.0	5	0.0	*
Region	15,862.2	1,124.1	7	0.0	*
MOUNTAIN					
Arizona	4,760.2	250.7	5	54.4	1
Colorado	4,030.1	1,261.4	31	26.7	*
Idaho	3,977.1	24.7	*	0.0	*
Montana	5,228.0	495.4	10	0.0	*
Nevada	356.6	130.8	37	0.0	*
New Mexico	4,733.9	1,210.2	26	123.2	3
Utah	3,234.6	1,480.0	46	127.9	4
Wyoming	987.1	254.0	26	0.0	*
Region	27,307.5	5,107.2	19	332.2	1
PACIFIC					
California	15,217.7	4,405.9	29	0.0	*
Oregon	11,889.2	2,003.5	17	0.0	*
Washington	12,690.2	216.0	2	0.0	*
Region	39,797.2	6,625.4	17	0.0	*
OTHER					
Hawaii	1,473.5	333.7	23	0.0	*
Puerto Rico	516.6	413.8	80	0.0	*
TOTAL	393,713.3	23,126.8	6	333.8	1

* = less than 1 percent.
Source: 1982 National Resources Inventory.

Appendix table 22a.--Annual sheet and rill erosion on rangeland, and the amount of erosion in excess of T, by erosion interval, 1982

Erosion interval (tons/acre)	Total acres (millions)	Cumulative percentage of acreage	Sheet & rill erosion (million tons)	Cumulative percentage of erosion	Erosion in excess of T (million tons)	Cumulative percentage of erosion in excess of T
>T+20	3.0	0.7	122.8	21.9	117.4	41.0
T+19 to T+20	0.2	0.7	4.2	22.6	3.8	42.4
T+18 to T+19	0.2	0.8	4.8	23.5	4.4	43.9
T+17 to T+18	0.3	0.9	5.8	24.5	5.2	45.7
T+16 to T+17	0.4	1.0	7.4	25.8	6.5	48.0
T+15 to T+16	0.3	1.0	4.9	26.7	4.3	49.5
T+14 to T+15	0.5	1.2	8.7	28.2	7.7	52.2
T+13 to T+14	0.5	1.3	8.3	29.7	7.3	54.8
T+12 to T+13	0.6	1.4	9.1	31.3	8.0	57.6
T+11 to T+12	0.8	1.6	10.2	33.1	8.8	60.6
T+10 to T+11	0.7	1.8	9.0	34.8	7.5	63.3
T+9 to T+10	0.9	2.0	10.2	36.6	8.4	66.2
T+8 to T+9	1.1	2.3	11.8	38.7	9.4	69.5
T+7 to T+8	1.3	2.6	12.0	40.8	9.4	72.8
T+6 to T+7	1.6	2.9	13.4	43.2	10.3	76.4
T+5 to T+6	2.1	3.5	15.8	46.0	11.7	80.5
T+4 to T+5	2.5	4.0	16.0	48.8	11.0	84.3
T+3 to T+4	3.6	4.9	19.7	52.3	12.6	88.8
T+2 to T+3	5.4	6.2	23.5	56.5	13.2	93.4
T+1 to T+2	8.4	8.2	27.1	61.4	12.1	97.6
T to T+1	18.4	12.5	34.5	67.5	6.9	100.0
<T	353.1	100.0	182.5	100.0	0.0	100.0
Total	405.9		561.7		285.9	

Source: 1982 National Resources Inventory.

Appendix table 22b.--Wind erosion on rangeland, and the amount of erosion in excess of T, by erosion interval, 1982

Erosion interval (tons/acre)	Total acres (millions)	Cumulative percentage of acreage	Wind erosion (million tons)	Cumulative percentage of erosion	Erosion in excess of T (million tons)	Cumulative percentage of erosion in excess of T
>T+20	6.3	1.5	453.8	74.5	427.4	83.1
T+19 to T+20	0.3	1.6	6.3	75.5	5.3	84.1
T+18 to T+19	0.3	1.6	7.5	76.7	6.3	85.3
T+17 to T+18	0.3	1.7	5.8	77.7	4.8	86.3
T+16 to T+17	0.5	1.8	10.7	79.4	8.6	87.9
T+15 to T+16	0.3	1.9	5.5	80.3	4.3	88.8
T+14 to T+15	0.4	2.0	7.7	81.6	6.0	90.0
T+13 to T+14	0.3	2.1	5.2	82.4	4.0	90.7
T+12 to T+13	0.3	2.1	5.2	83.3	4.2	91.5
T+11 to T+12	0.4	2.2	5.6	84.2	4.1	92.4
T+10 to T+11	0.3	2.3	4.4	84.9	3.2	93.0
T+9 to T+10	0.5	2.4	6.3	85.9	4.7	93.9
T+8 to T+9	0.7	2.6	8.3	87.3	6.2	95.1
T+7 to T+8	0.6	2.7	6.1	88.3	4.1	95.9
T+6 to T+7	0.8	2.9	7.7	89.6	4.9	96.8
T+5 to T+6	0.8	3.1	6.9	90.7	4.4	97.7
T+4 to T+5	0.6	3.2	5.1	91.5	2.9	98.2
T+3 to T+4	0.7	3.4	4.3	92.2	2.3	98.7
T+2 to T+3	1.4	3.7	7.3	93.4	3.4	99.4
T+1 to T+2	1.6	4.1	6.7	94.5	2.3	99.8
T to T+1	4.4	5.1	6.9	95.7	1.0	100.0
<T	384.2	100.0	26.3	100.0	0.0	100.0
Total	405.9		609.5		514.4	

Source: 1982 National Resources Inventory.

Appendix table 23.--Estimated annual effects and cumulative net value of 100 years of erosion (under 1982 management conditions) on the nation's productive capacity, by farming region

Farming region	Cropland acres 1/ (1,000)	Annual loss: Productivity (percent)	Annual loss: "Equivalent acres" 2/ (1,000 acres)	Annual loss: Gross product ($1,000) 3/	Cumulative (100-year) net value ($1,000) 3/
		Sheet and rill erosion			
Northeast	17,260	0.000508	2.8	1,736	1,020,167
Lake States	43,924	0.000073	3.2	635	373,072
Corn Belt	92,395	0.000283	26.1	5,177	3,042,307
Northern Plains	93,381	0.000044	4.1	814	478,059
Appalachia	22,711	0.000370	8.4	1,664	977,703
Southeast	18,214	0.000103	1.9	372	218,604
Delta States	21,926	0.000139	3.0	603	354,597
Southern Plains	44,888	0.000015	0.7	133	78,341
Mountain	43,294	0.000023	1.0	197	115,859
Pacific	22,667	0.000193	4.4	866	509,012
United States (contiguous)	421,000	0.000146	61.6	12,198	7,167,720
		Wind erosion			
Northeast	17,260	0.000003	0.1	10	6,025
Lake States	43,924	0.000090	4.0	783	459,952
Corn Belt	92,395	0.000015	1.4	274	161,253
Northern Plains	93,381	0.000028	2.6	518	304,219
Appalachia	22,711	0.000000	0.0	0	0
Southeast	18,214	0.000000	0.0	0	0
Delta States	21,926	0.000000	0.0	0	0
Southern Plains	44,888	0.000109	5.0	96	569,275
Mountain	43,294	0.000088	3.8	754	443,285
Pacific	22,667	0.000044	1.0	198	116,044
United States	421,000	0.000042	17.7	3,506	2,060,053

1/ 1982 NRI total.
2/ "Equivalent acres" are the number of additional acres needed, after 100 years of erosion, to produce the amount of crops currently produced.
3/ Monetary loss estimates are in constant 1980 dollars. "Gross product loss" is calculated by multiplying the equivalent acres by the national average value of production of the major crops.

Source: EPIC/EPIS.

Appendix table 24.--Percentage of productivity lost as a result of sheet and rill erosion, under 1982 management, by state portion of land resource region (LRR): 100th-year estimate

State	LRR 1/	Loss	State	LRR 1/	Loss	State	LRR 1/	Loss
Alabama	N	6.8	Maryland	T	0.3	Oregon	B	1.4
Alabama	P	1.5	Massachusetts	R	2.2	Oregon	D	0.3
Alabama	T	1.1	Michigan	L	1.1	Pennsylvania	L	3.2
Arkansas	N	5.6	Michigan	M	4.1	Pennsylvania	N	4.7
Arkansas	O	0.5	Minnesota	K	1.1	Pennsylvania	R	9.9
Arkansas	P	5.5	Minnesota	M	1.4	Pennsylvania	S	5.5
California	A	57.7	Mississippi	O	0.6	Rhode Island	R	2.0
California	C	17.7	Mississippi	P	6.5	South Carolina	N	4.5
Colorado	D	0.2	Missouri	M	5.1	South Carolina	P	1.4
Connecticut	R	2.9	Missouri	N	2.6	South Carolina	T	0.1
Delaware	S	1.0	Missouri	O	2.7	South Dakota	F	0.2
Delaware	T	0.4	Missouri	P	10.5	South Dakota	G	4.9
Florida	P	0.9	Montana	E	1.2	South Dakota	M	0.9
Georgia	N	21.6	Nebraska	H	1.0	Tennessee	N	7.1
Georgia	P	1.1	Nebraska	M	3.8	Tennessee	O	6.5
Georgia	T	0.8	New Hampshire	R	0.8	Tennessee	P	6.2
Idaho	B	2.1	New Jersey	L	11.1	Texas	J	1.5
Idaho	E	5.2	New Jersey	S	5.2	Texas	P	1.0
Illinois	L	4.8	New York	L	13.4	Utah	E	11.7
Illinois	M	5.1	New York	R	5.1	Vermont	R	1.3
Indiana	L	1.9	New York	S	11.1	Virginia	N	13.0
Indiana	M	8.0	North Carolina	N	10.9	Virginia	P	0.7
Indiana	N	14.9	North Carolina	P	3.2	Virginia	S	12.7
Iowa	M	3.8	North Carolina	T	0.3	Virginia	T	3.8
Kansas	H	0.2	North Dakota	F	0.1	Washington	A	5.5
Kansas	M	1.4	North Dakota	G	1.0	Washington	B	2.8
Kentucky	N	10.9	Ohio	L	4.9	Washington	E	1.3
Kentucky	O	4.9	Ohio	M	5.4	West Virginia	N	5.2
Kentucky	P	8.2	Ohio	N	6.3	West Virginia	S	0.2
Louisiana	O	1.9	Ohio	R	6.0	Wisconsin	K	0.1
Louisiana	P	3.8	Oklahoma	J	0.9	Wisconsin	L	2.1
Louisiana	T	1.3	Oklahoma	M	0.6	Wisconsin	M	1.3
Maine	R	4.8	Oklahoma	H	0.1			
Maryland	N	6.7	Oklahoma	N	0.4			
Maryland	S	11.1	Oregon	A	6.1			

1/ Only those portions of land resource regions that would experience a loss in crop productivity are displayed.

Source: EPIC/EPIS estimates.

Appendix table 25.--"Equivalent acres" required to compensate for productivity lost through sheet and rill erosion, under 1982 management, by state portion of land resource region (LRR): 100th-year estimate

State	LRR 1/	Equivalent acres loss 2/	State	LRR 1/	Equivalent acres loss 2/	State	LRR 1/	Equivalent acres loss 2/
		(1,000 acres)			(1,000 acres)			(1,000 acres)
Alabama	N	62.9	Maryland	N	4.8	Oklahoma	N	0.3
Alabama	P	29.4	Maryland	S	76.2	Oregon	A	27.1
Alabama	T	0.1	Maryland	T	1.3	Oregon	B	21.9
Arkansas	N	13.1	Massachusetts	R	3.8	Oregon	D	0.3
Arkansas	O	1.5	Michigan	L	32.7	Pennsylvania	L	0.6
Arkansas	P	32.8	Michigan	M	14.6	Pennsylvania	N	47.3
California	A	12.7	Minnesota	K	21.2	Pennsylvania	R	251.3
California	C	222.5	Minnesota	M	81.8	Pennsylvania	S	33.5
Colorado	D	0.4	Mississippi	O	0.6	Rhode Island	R	0.2
Colorado	H	0.1	Mississippi	P	107.9	South Carolina	N	0.4
Connecticut	R	4.1	Missouri	M	380.3	South Carolina	P	11.7
Delaware	S	0.6	Missouri	N	25.6	South Carolina	T	0.1
Delaware	T	0.4	Missouri	O	1.4	South Dakota	F	3.4
Florida	P	2.8	Missouri	P	5.2	South Dakota	G	44.3
Florida	U	0.1	Montana	E	10.7	South Dakota	M	20.2
Georgia	N	17.5	Nebraska	H	50.3	Tennessee	N	105.8
Georgia	P	34.7	Nebraska	M	196.0	Tennessee	O	0.3
Georgia	T	0.5	New Hampshire	R	0.7	Tennessee	P	83.6
Idaho	B	63.4	New Jersey	L	37.9	Texas	J	44.1
Idaho	E	7.7	New Jersey	S	4.0	Texas	P.	2.1
Illinois	L	42.0	New York	L	181.7	Utah	E	6.1
Illinois	M	525.7	New York	R	78.1	Vermont	R	4.3
Indiana	L	2.3	New York	S	1.0	Virginia	N	43.4
Indiana	M	300.9	North Carolina	N	14.3	Virginia	P	8.9
Indiana	N	86.0	North Carolina	P	74.1	Virginia	S	59.7
Iowa	M	616.8	North Carolina	T	0.5	Virginia	T	2.9
Kansas	H	17.5	North Dakota	F	10.9	Washington	A	3.8
Kansas	M	42.0	North Dakota	G	2.3	Washington	B	133.9
Kentucky	N	329.9	Ohio	L	5.5	Washington	E	1.6
Kentucky	O	0.3	Ohio	M	182.9	West Virginia	N	24.2
Kentucky	P	27.4	Ohio	N	58.1	West Virginia	S	0.4
Louisiana	O	1.1	Ohio	R	63.1	Wisconsin	K	3.4
Louisiana	P	12.8	Oklahoma	H	1.4	Wisconsin	L	70.0
Louisiana	T	0.7	Oklahoma	J	2.3	Wisconsin	M	40.4
Maine	R	27.6	Oklahoma	M	1.1			

1/ Only those portions of land resource regions that would experience a loss in crop productivity are displayed.
2/ "Equivalent acres" are the number of additional acres that would be needed, after 100 years of erosion, to produce the amount of crops currently produced.

Source: EPIC/EPIS estimates.

Appendix table 26.--Gross product loss resulting from sheet and rill erosion, 1982 management, by state portion of land resource region (LRR): 100th-year estimate

State	LRR 1/	Gross product loss	State	LRR 1/	Gross product loss	State	LRR 1/	"Gross Product" Loss
		($1,000)			($1,000)			($1,000)
Alabama	N	12,456	Maryland	N	952	Oklahoma	N	50
Alabama	P	5,811	Maryland	S	15,096	Oregon	A	5,364
Alabama	T	28	Maryland	T	257	Oregon	B	4,328
Arkansas	N	2,596	Massachusetts	R	752	Oregon	D	59
Arkansas	O	295	Michigan	L	6,481	Pennsylvania	L	117
Arkansas	P	6,488	Michigan	M	2,881	Pennsylvania	N	9,367
California	A	2,511	Minnesota	K	4,198	Pennsylvania	R	49,763
California	C	44,055	Minnesota	M	16,202	Pennsylvania	S	6,633
Colorado	D	71	Mississippi	O	127	Rhode Island	R	48
Colorado	H	10	Mississippi	P	21,362	South Carolina	N	69
Connecticut	R	804	Missouri	M	75,305	South Carolina	P	2,315
Delaware	S	121	Missouri	N	5,073	South Carolina	T	12
Delaware	T	73	Missouri	O	281	South Dakota	F	681
Florida	P	550	Missouri	P	1,022	South Dakota	G	8,779
Florida	U	12	Montana	E	2,113	South Dakota	M	4,008
Georgia	N	3,461	Nebraska	H	9,951	Tennessee	N	20,954
Georgia	P	6,869	Nebraska	M	38,798	Tennessee	O	65
Georgia	T	97	New Hampshire	R	129	Tennessee	P	16,547
Idaho	B	12,545	New Jersey	L	7,510	Texas	J	8,736
Idaho	E	1,517	New Jersey	S	786	Texas	P	416
Illinois	L	8,320	New York	L	35,979	Texas	T	8
Illinois	M	104,093	New York	R	15,466	Utah	E	1,200
Indiana	L	446	New York	S	194	Vermont	R	845
Indiana	M	59,570	North Carolina	N	2,825	Virginia	N	8,599
Indiana	N	17,024	North Carolina	P	14,676	Virginia	P	1,752
Iowa	M	122,124	North Carolina	T	97	Virginia	S	11,825
Kansas	H	3,459	North Dakota	F	2,156	Virginia	T	574
Kansas	M	8,314	North Dakota	G	453	Washington	A	760
Kentucky	N	65,312	Ohio	L	1,093	Washington	B	26,504
Kentucky	O	59	Ohio	M	36,220	Washington	E	311
Kentucky	P	5,415	Ohio	N	11,498	West Virginia	N	4,784
Louisiana	O	212	Ohio	R	12,484	West Virginia	S	87
Louisiana	P	2,526	Oklahoma	H	279	Wisconsin	K	677
Louisiana	T	147	Oklahoma	J	449	Wisconsin	L	13,862
Maine	R	5,459	Oklahoma	M	220	Wisconsin	M	8,007

1/ Only those portions of land resource regions that would experience a loss in gross product are displayed.

Source: EPIC/EPIS.

Appendix table 27.--Percentage of productivity lost due to wind erosion, 1982 erosion rates, by state portion of land resource region (LRR): 100th-year estimate

State	LRR 1/	Loss	State	LRR 1/	Loss
California	D	0.7	North Dakota	G	0.6
Colorado	D	0.3	Oklahoma	H	0.2
Colorado	E	3.4	Oklahoma	J	1.3
Colorado	G	4.1	Oregon	B	0.5
Colorado	H	0.4	Oregon	D	0.4
Idaho	B	1.2	South Dakota	F	0.2
Kansas	H	0.4	South Dakota	G	5.0
Montana	D	0.7	Texas	D	2.9
Montana	E	2.6	Texas	H	4.3
Montana	G	1.1	Texas	I	1.7
Nebraska	G	0.7	Texas	T	0.5
Nevada	D	38.6	Utah	D	0.2
New Mexico	D	1.2	Washington	B	0.6
New Mexico	G	0.1	Wyoming	G	0.2
New Mexico	H	1.1			

1/ Only those state portions of land resource regions that would experience a loss in crop productivity are displayed.

Source: EPIC/EPIS estimates.

Appendix table 28.--"Equivalent acres" required to compensate for productivity lost through wind erosion, 1982 management, by state portion of land resource region (LRR): 100th-year estimate

State	LRR 1/	Equivalent acres loss	State	LRR 1/	Equivalent acres loss
		(1,000 acres)			(1,000 acres)
California	D	2.7	North Dakota	G	1.5
Colorado	D	1.1	Oklahoma	H	15.5
Colorado	E	10.2	Oklahoma	J	3.6
Colorado	G	111.7	Oregon	B	9.1
Colorado	H	5.4	Oregon	D	0.3
Idaho	B	65.6	South Dakota	F	3.8
Kansas	H	43.1	South Dakota	G	46.2
Montana	E	26.5	Texas	D	2.8
Montana	G	51.8	Texas	H	342.5
Montana	F	30.0	Texas	I	18.0
Nebraska	G	19.0	Texas	J	16.4
Nevada	D	31.2	Texas	T	0.4
New Mexico	D	2.8	Utah	D	0.9
New Mexico	G	0.2	Washington	B	75.6
New Mexico	H	6.6	Wyoming	G	2.6
North Dakota	F	0.6			

1/ Only those state portions of land resource regions that would experience a loss in crop productivity are displayed.

Source: EPIC/EPIS estimates.

Appendix table 29.--"Gross product loss" resulting from wind erosion on cropland classified e or VIs, VIIs, VIII, under 1982 management, by state portion of land resource region (LRR): 100th-year estimate

State	LRR 1/	Gross product loss ($1,000)	State	LRR 1/	Gross product loss ($1,000)
California	D	544	North Dakota	G	299
Colorado	D	215	Oklahoma	H	3,074
Colorado	E	2,023	Oklahoma	J	713
Colorado	G	22,113	Oregon	B	1,806
Colorado	H	1,076	Oregon	D	63
Idaho	B	12,980	South Dakota	F	755
Kansas	H	8,533	South Dakota	G	755
Montana	D	5	South Dakota	M	4
Montana	E	5,251	Texas	D	547
Montana	G	10,248	Texas	H	67,806
Nebraska	G	3,769	Texas	I	3,569
Nevada	D	6,187	Texas	T	75
New Mexico	D	562	Utah	D	178
New Mexico	G	34	Washington	B	14,968
New Mexico	H	1,302	Wyoming	G	516
North Dakota	F	126			

1/ Only those state portions of land resource regions that would experience a loss in gross product are displayed.

Source: EPIC/EPIS estimates.

Appendix table 30.--Cropland and pastureland soils affected by saline and/or sodic conditions

State	Sodic 1/ soils	Saline 1/ soils	Slightly 1/ saline soils	Total affected soils	Total cropland/ pastureland
	(1,000 acres)				
NORTHEAST					
Connecticut	0.0	0.0	0.0	0.0	358.7
Delaware	0.0	0.0	0.0	0.0	554.3
Maine	0.0	0.0	0.0	0.0	1,522.4
Maryland	0.0	0.0	0.0	0.0	2,328.5
Massachusetts	0.0	0.0	0.0	0.0	498.8
New Hampshire	0.0	0.0	0.0	0.0	282.3
New Jersey	0.0	0.0	0.0	0.0	1,049.0
New York	0.0	0.0	0.0	0.0	9,783.9
Pennsylvania	0.0	0.0	0.0	0.0	8,488.9
Rhode Island	0.0	0.0	0.0	0.0	63.1
Vermont	0.0	0.0	0.0	0.0	1,149.1
Region	0.0	0.0	0.0	0.0	26,079.0
APPALACHIA					
Kentucky	0.0	0.0	0.0	0.0	11,814.0
North Carolina	0.0	0.0	2.8	2.8	8,675.0
Tennessee	0.0	0.0	0.0	0.0	10,947.7
Virginia	0.0	0.0	0.0	0.0	6,788.9
West Virginia	0.0	0.0	0.0	0.0	2,962.2
Region	0.0	0.0	2.8	2.8	41,187.8
SOUTHEAST					
Alabama	0.0	0.0	0.0	0.0	8,326.9
Florida	0.0	16.4	9.4	25.8	7,830.0
Georgia	0.0	4.9	0.0	4.9	9,545.0
South Carolina	0.0	0.0	0.0	0.0	4,786.7
Region	0.0	21.3	9.4	30.7	30,488.6
LAKE STATES					
Michigan	0.0	0.0	0.0	0.0	12,354.1
Minnesota	0.0	69.6	2,691.3	2,760.9	26,613.9
Wisconsin	0.0	0.0	0.0	0.0	14,851.0
Region	0.0	69.6	2,691.3	2,760.9	53,819.0
CORN BELT					
Illinois	269.3	0.0	0.0	269.3	27,884.7
Indiana	0.0	0.0	0.0	0.0	15,993.2
Iowa	0.0	0.0	13.5	13.5	30,976.8
Missouri	35.5	0.0	72.0	107.5	27,571.4
Ohio	0.0	0.0	0.0	0.0	15,161.0
Region	304.8	0.0	85.5	390.3	117,587.1
DELTA STATES					
Arkansas	629.7	0.0	0.0	629.7	13,895.3
Louisiana	67.3	40.8	52.9	161.0	8,777.4
Mississippi	18.1	0.0	0.0	18.1	11,390.5
Region	715.1	40.8	52.9	808.8	34,063.2
NORTHERN PLAINS					
Kansas	103.4	20.6	1,043.1	1,167.1	31,359.2
Nebraska	111.4	142.5	86.2	340.1	22,402.0
North Dakota	1,272.8	1,449.6	6,715.8	9,438.2	28,311.1
South Dakota	1,379.9	512.7	7,187.1	9,079.7	19,650.2
Region	2,867.5	2,125.4	15,032.2	20,025.1	101,722.5

Appendix table 30.--Cropland and pastureland soils affected by saline and/or sodic conditions --continued

State	Sodic 1/ soils	Saline 1/ soils	Slightly 1/ saline soils	Total affected soils	Total cropland/ pastureland
			(1,000 acres)		
SOUTHERN PLAINS					
Oklahoma	306.0	31.3	107.9	445.2	18,706.0
Texas	191.4	1,301.2	2,999.7	4,492.3	50,362.4
Region	497.4	1,332.5	3,107.6	4,937.5	69,068.4
MOUNTAIN					
Arizona	17.8	101.7	727.8	847.3	1,285.6
Colorado	157.4	782.2	883.0	1,822.6	11,862.4
Idaho	13.9	767.7	876.4	1,658.0	7,664.3
Montana	572.6	1,314.7	5,012.3	6,899.6	20,232.9
Nevada	15.7	618.6	218.5	852.8	1,164.1
New Mexico	15.4	138.5	523.9	677.8	2,576.0
Utah	141.3	413.5	580.1	1,134.9	2,529.0
Wyoming	16.7	576.4	512.8	1,105.9	3,342.2
Region	950.8	4,713.3	9,334.8	14,998.9	50,656.5
PACIFIC					
California	846.6	1,959.4	1,112.9	3,918.9	11,910.2
Oregon	24.2	118.9	118.3	261.4	6,322.3
Washington	27.4	61.0	228.6	317.0	9,138.0
Region	898.2	2,139.3	1,459.8	4,497.3	27,370.5
OTHER					
Hawaii	0.0	0.0	0.0	0.0	1,307.2
Caribbean	0.0	15.8	0.0	15.8	1,363.3
Region	0.0	15.8	0.0	15.8	2,670.5
TOTAL	6,233.8	10,458.0	31,776.3	48,468.1	554,713.1

Source: 1982 National Resources Inventory and National Cooperative Soil Survey.

Saline soils have relatively high amounts of water-soluble salts but have a low accumulation of sodium on the exchange complex. Their defining characteristics are: conductivity of more than 4 mmhos/cm of the saturation extract, and less than 15 percent exchangeable sodium. Slightly saline soils are defined as similar to soils except that the conductivity of the saturation extract is between 2 and 4 mmhos/cm.

The data for salinity in appendix tables 30 and 31 were obtained by cross-referencing the conductivity values for each soil series (according to the Soil Interpretations Record for soils of the United States) with acreage figures from the 1982 National Resources Inventory (NRI). Conductivity values are recorded as ranges for major soil layers. The maximum value of the range was adjusted by the layer's position in the soil profile, as follows:

Depth below soil surface (in.)	Adjustment factors (%)
0-10	40
10-20	30
20-30	20
30-40	10
	100

The adjustment factors correlate with the proportion of water extracted by crops at increasing depths (J.D. Rhoades, ARS, Riverside, CA; personal communication).

Sodic soils have a high saturation of sodium on the exchange complex and have a relatively low content of soluble salts. Their defining characteristics are: 15 percent or more exchangeable sodium, and conductivity of less than 4 mmhos/cm of the saturation extract. Saline-sodic soils are defined as soils that have 15 percent or more exchangeable sodium and a conductivity of 4 mmhos/cm or more. In tables 30 and 31, the acreages of sodic and saline-sodic soils are combined under the designation "Sodic soils."

Appendix table 31.--Irrigated cropland and pastureland soils affected by saline or sodic conditions

State	Sodic 1/ soils	Saline 1/ soils	Slightly 1/ saline soils	Total affected soils	Total cropland/ pastureland
			(1,000 acres)		
NORTHEAST					
Connecticut	0.0	0.0	0.0	0.0	9.8
Delaware	0.0	0.0	0.0	0.0	49.5
Maine	0.0	0.0	0.0	0.0	11.2
Maryland	0.0	0.0	0.0	0.0	46.5
Massachusetts	0.0	0.0	0.0	0.0	18.1
New Hampshire	0.0	0.0	0.0	0.0	2.9
New Jersey	0.0	0.0	0.0	0.0	118.9
New York	0.0	0.0	0.0	0.0	62.6
Pennsylvania	0.0	0.0	0.0	0.0	10.9
Rhode Island	0.0	0.0	0.0	0.0	3.8
Vermont	0.0	0.0	0.0	0.0	1.4
Region	0.0	0.0	0.0	0.0	335.6
APPALACHIA					
Kentucky	0.0	0.0	0.0	0.0	18.7
North Carolina	0.0	0.0	0.0	0.0	281.5
Tennessee	0.0	0.0	0.0	0.0	18.3
Virginia	0.0	0.0	0.0	0.0	99.6
West Virginia	0.0	0.0	0.0	0.0	2.8
Region	0.0	0.0	0.0	0.0	420.9
SOUTHEAST					
Alabama	0.0	0.0	0.0	0.0	91.5
Florida	0.0	0.0	6.3	6.3	2,380.7
Georgia	0.0	2.4	0.0	2.4	1,072.8
South Carolina	0.0	0.0	0.0	0.0	95.3
Region	0.0	2.4	6.3	8.7	3,640.3
LAKE STATES					
Michigan	0.0	0.0	0.0	0.0	398.2
Minnesota	0.0	0.0	5.5	5.5	400.7
Wisconsin	0.0	0.0	0.0	0.0	326.7
Region	0.0	0.0	5.5	5.5	1,125.6
CORN BELT					
Illinois	0.0	0.0	0.0	0.0	167.8
Indiana	0.0	0.0	0.0	0.0	150.8
Iowa	0.0	0.0	0.0	0.0	159.5
Missouri	1.3	0.0	3.7	5.0	738.7
Ohio	0.0	0.0	0.0	0.0	33.1
Region	1.3	0.0	3.7	5.0	1,249.9
DELTA STATES					
Arkansas	445.7	0.0	0.0	445.7	3,305.1
Louisiana	12.0	23.4	0.0	35.4	1,290.3
Mississippi	0.0	0.0	0.0	0.0	579.4
Region	457.7	23.4	0.0	481.1	5,174.8
NORTHERN PLAINS					
Kansas	9.9	5.6	139.1	154.6	3,502.0
Nebraska	93.4	78.0	43.5	214.9	7,169.5
North Dakota	7.4	3.2	17.9	28.5	204.7
South Dakota	6.6	65.6	117.1	189.3	505.1
Region	117.3	152.4	317.6	587.3	11,381.3

Appendix table 31.--Irrigated cropland and pastureland soils affected by saline or sodic conditions--continued

State	Sodic 1/ soils	Saline 1/ soils	Slightly 1/ saline soils	Total affected soils	Total cropland/ pastureland
			(1,000 acres)		
SOUTHERN PLAINS					
Oklahoma	0.0	0.0	12.9	12.9	789.0
Texas	7.9	419.6	1,127.8	1,555.3	9,963.2
Region	7.9	419.6	1,140.7	1,568.2	10,752.2
MOUNTAIN					
Arizona	17.8	101.7	723.6	843.1	1,256.8
Colorado	94.9	562.3	443.7	1,100.9	3,672.9
Idaho	5.5	671.5	748.4	1,425.4	4,105.7
Montana	83.0	222.8	618.2	924.0	2,676.2
Nevada	14.8	592.0	196.7	803.5	1,092.2
New Mexico	15.4	124.4	506.7	646.5	1,526.0
Utah	102.6	337.4	397.7	837.7	1,659.9
Wyoming	13.6	323.3	392.7	729.6	1,641.2
Region	347.6	2,935.4	4,027.7	7,310.7	17,630.9
PACIFIC					
California	756.9	1,774.4	1,064.2	3,595.5	9,820.8
Oregon	19.9	101.2	77.3	198.4	2,221.2
Washington	0.0	28.3	125.1	153.4	1,816.6
Region	776.8	1,903.9	1,266.6	3,947.3	13,858.6
OTHER					
Hawaii	0.0	0.0	0.0	0.0	220.4
Caribbean	0.0	5.8	0.0	5.8	91.8
Region	0.0	5.8	0.0	5.8	312.2
TOTAL	1,708.6	5,442.9	6,768.1	13,919.6	65,882.3

Source: 1982 National Resources Inventory and National Cooperative Soil Survey.

Saline soils have relatively high amounts of water-soluble salts but have a low accumulation of sodium on the exchange complex. Their defining characteristics are: conductivity of more than 4 mmhos/cm of the saturation extract, and less than 15 percent exchangeable sodium. Slightly saline soils are defined as similar to soils except that the conductivity of the saturation extract is between 2 and 4 mmhos/cm.

The data for salinity in appendix tables 30 and 31 were obtained by cross-referencing the conductivity values for each soil series (according to the Soil Interpretations Record for soils of the United States) with acreage figures from the 1982 National Resources Inventory (NRI). Conductivity values are recorded as ranges for major soil layers. The maximum value of the range was adjusted by the layer's position in the soil profile, as follows:

Depth below soil surface (in.)	Adjustment factors (%)
0-10	40
10-20	30
20-30	20
30-40	10
	100

The adjustment factors correlate with the proportion of water extracted by crops at increasing depths (J.D. Rhoades, ARS, Riverside, CA; personal communication).

Sodic soils have a high saturation of sodium on the exchange complex and have a relatively low content of soluble salts. Their defining characteristics are: 15 percent or more exchangeable sodium, and conductivity of less than 4 mmhos/cm of the saturation extract. Saline-sodic soils are defined as soils that have 15 percent or more exchangeable sodium and a conductivity of 4 mmhos/cm or more. In tables 30 and 31, the acreages of sodic and saline-sodic soils are combined under the designation "Sodic soils."

Appendix table 32.--Rangeland condition on nonfederal rangeland, by state

State	Excellent	Good	Fair	Poor	Other	Total
	------------------------------1,000 acres------------------------------					
Arizona	517.7	4,923.6	16,574.1	8,831.9	100.9	30,948.2
Arkansas	4.9	21.5	70.2	68.0	0.0	164.6
California	29.3	472.9	613.2	434.0	16,575.2	18,124.6
Colorado	333.2	5,802.6	14,012.2	4,033.2	41.3	24,222.5
Florida	24.5	272.5	1,831.4	1,640.1	35.4	3,803.9
Idaho	322.6	2,187.3	2,565.9	1,255.3	401.8	6,732.9
Kansas	965.5	8,091.9	6,121.9	1,666.2	63.4	16,908.9
Louisiana	12.5	148.5	54.0	26.3	0.0	241.3
Minnesota	20.4	47.8	100.3	27.6	2.4	198.5
Missouri	1.3	56.2	49.7	55.6	5.0	167.8
Montana	5,027.5	17,272.1	12,605.1	2,747.2	185.1	37,837.0
Nebraska	2,188.5	12,636.1	7,110.2	1,069.0	91.9	23,095.7
Nevada	239.2	2,674.4	4,027.0	658.8	308.4	7,907.8
New Mexico	658.7	12,262.5	22,617.4	5,421.5	21.8	40,981.9
North Dakota	1,524.2	6,295.3	2,760.7	368.2	0.0	10,948.4
Oklahoma	906.8	3,601.6	7,638.6	2,903.9	8.7	15,059.6
Oregon	226.4	1,813.2	3,485.5	3,731.1	135.8	9,392.0
South Dakota	1,876.7	13,715.9	6,486.0	704.0	1.0	22,783.6
Texas	479.9	13,546.3	53,542.8	25,680.6	2,103.5	95,353.1
Utah	154.9	1,724.5	4,027.0	2,451.3	131.6	8,489.3
Washington	629.0	1,168.5	1,816.1	1,933.0	90.4	5,637.0
Wyoming	331.0	11,609.6	13,988.1	976.4	10.0	26,915.1
Total	16,474.7	120,344.8	182,097.4	66,683.2	20,313.6	405,913.7

Source: 1982 National Resources Inventory.

Rangeland condition is the relative degree, expressed as a percentage, to which the kinds, proportions, and amounts of plants in the present plant community resemble those of the climax vegetation (potential natural plant community) for the site. The five rangeland condition classes are:

Excellent: More than 75 percent resemblance to the climax community;

Good: 51 to 75 percent;

Fair: 26 to 50 percent;

Poor: 0 to 25 percent; and

Other: Land where ecological condition ratings are not applicable; includes land that has been seeded to non-native species and California's annual grasslands.

Appendix table 33.--Conservation treatment needs on nonfederal rangeland, by state

State	Adequately 1/ protected	Treatment 2/ not feasible	Treatment 3/ needed	Total nonfederal rangeland
	---1,000 acres---			
Arizona	6,204.9	1,791.2	22,952.1	30,948.2
Arkansas	29.5	25.2	109.9	164.6
California	6,323.4	4,050.8	7,750.4	18,124.6
Colorado	6,366.6	1,253.5	16,602.4	24,222.5
Florida	658.7	163.1	2,982.1	3,803.9
Idaho	1,505.1	399.4	4,828.4	6,732.9
Kansas	7,948.4	82.2	8,878.3	16,908.9
Louisiana	33.3	15.2	192.8	241.3
Minnesota	115.7	8.4	74.4	198.5
Missouri	34.7	0.0	133.1	167.8
Montana	16,994.1	1,592.1	19,250.8	37,837.0
Nebraska	15,887.7	82.4	7,125.6	23,095.7
Nevada	2,311.5	1,359.3	4,237.0	7,907.8
New Mexico	11,360.4	1,192.0	28,429.5	40,981.9
North Dakota	7,585.9	207.6	3,154.9	10,948.4
Oklahoma	5,636.9	249.8	9,172.9	15,059.6
Oregon	1,145.9	692.7	7,553.4	9,392.0
South Dakota	13,460.6	256.3	9,066.7	22,783.6
Texas	21,778.2	2,599.0	70,975.9	95,353.1
Utah	1,141.5	276.6	7,071.2	8,489.3
Washington	1,538.7	314.8	3,783.5	5,637.0
Wyoming	8,222.7	2,296.7	16,395.7	26,915.1
TOTAL	136,284.4	18,908.3	250,721.0	405,913.7

1/ Soil erosion and other factors that limit sustained productive use of the resource are within acceptable limits.
2/ A conservation problem exists, but the treatment of the problem is not feasible because a reasonable return on the treatment investment is unlikely.
3/ See appendix table 34 for types of treatment needed.

Source: 1982 National Resources Inventory.

Appendix table 34.--Types of treatment needed on nonfederal rangeland, by state

State	Erosion 1/ control	Protection 2/	Improvement 3/	Improvement 4/ and brush management	Reestab- 5/ lishment	Brush manage- 6/ ment and reestablish- ment
	1,000 acres					
Arizona	1,369.9	8,234.7	8,420.0	1,980.4	1,355.0	1,592.1
Arkansas	6.6	6.6	5.2	17.1	0.0	74.4
California	2,248.4	3,257.5	916.3	756.6	404.8	166.8
Colorado	2,960.4	5,739.7	3,846.4	2,416.8	1,053.5	585.6
Florida	15.1	159.8	891.9	1,783.0	30.9	101.4
Idaho	227.6	1,169.5	715.5	1,951.0	359.4	405.4
Kansas	499.8	3,103.5	2,463.9	2,270.0	334.7	206.4
Louisiana	0.2	97.3	19.2	76.1	0.0	0.0
Minnesota	1.0	38.1	29.3	6.0	0.0	0.0
Missouri	9.8	19.6	11.4	64.4	3.1	24.8
Montana	555.3	11,353.9	4,988.9	1,753.8	503.4	95.5
Nebraska	351.2	3,241.1	2,473.0	581.8	455.3	23.2
Nevada	256.0	738.5	610.3	1,969.4	232.1	430.7
New Mexico	8,162.8	7,006.5	6,705.4	5,271.5	726.5	556.5
North Dakota	288.4	2,059.0	591.2	148.4	67.9	0.0
Oklahoma	731.8	1,834.5	2,634.7	2,984.5	650.8	336.6
Oregon	899.4	782.7	1,970.1	2,205.0	547.3	1,248.9
South Dakota	485.7	5,946.2	2,391.0	111.1	131.6	1.1
Texas	1,332.0	7,479.5	17,834.0	31,320.6	2,827.0	10,182.8
Utah	1,918.6	2,622.0	632.9	1,027.1	182.0	688.6
Washington	303.3	824.9	815.1	673.0	631.6	535.6
Wyoming	2,535.1	5,102.7	4,531.2	3,845.6	275.4	105.7
TOTAL	25,158.4	70,717.8	63,496.9	63,213.2	10,772.3	17,362.4

1/ Existing treatment is inadequate for sustained use of the resource base. Erosion control practices are needed to dispose of surface water runoff at nonerosive velocities, and/or erosion control practices are needed to reduce soil movement by wind or water to within the tolerable limits established for each soil.

2/ Plant cover needs to be protected from overgrazing. The desired vegetation is present but has been damaged by overgrazing, and only livestock management and distribution are needed to enable the vegetation to recover and reseed naturally.

3/ The forage cover is inadequate but can be improved or restored by applying recommended management practices and following recommended grazing systems.

4/ The encroachment of woody and noxious plants has destroyed or threatens the grass cover, and chemical or mechanical measures are needed to permit satisfactory growth.

5/ The pasture or range vegetation is in such poor condition that it needs complete reestablishment without brush control measures.

6/ Both brush control and reestablishment of vegetation are needed to permit the growth of a satisfactory grass cover.

Source: 1982 National Resources Inventory.

Appendix table 35.--Average number of animal units on each ranch size in the 17 western states, 1982

State	Small	Medium	Large
Arizona	68	292	1473
California	61	302	1259
Colorado	79	303	1803
Idaho	78	284	1136
Kansas	75	240	2688
Montana	68	275	1320
Nebraska	70	249	2013
Nevada	95	334	1184
New Mexico	94	228	660
North Dakota	65	266	1268
Oklahoma	59	283	1020
Oregon	73	301	1275
South Dakota	70	269	1364
Texas	61	270	1657
Utah	82	303	1046
Washington	66	256	1036
Wyoming	75	262	1309

Source: John Fowler, 1986.

Appendix table 36.--Percentage of ranch operations in each size class in the 17 western states, 1982

State	Small (1-100 head)	Medium (200-499 head)	Large (500 + head)
Arizona[1]	70.7	18.1	11.2
California	82.9	11.4	5.6
Colorado	69.5	25.8	4.7
Idaho	76.8	20.0	3.2
Kansas	74.7	22.0	3.3
Montana	52.5	37.5	10.0
Nebraska	60.7	32.9	6.4
Nevada[1]	72.5	20.2	7.3
New Mexico	76.9	16.8	6.3
North Dakota	59.5	38.6	1.9
Oklahoma	80.3	17.9	1.8
Oregon[1]	79.1	18.3	2.6
South Dakota	52.0	43.2	4.8
Texas	86.0	11.6	2.4
Utah[1]	75.3	21.5	3.2
Washington[1]	85.7	12.8	1.5
Wyoming	49.1	36.4	14.5

[1] Individual state "Agricultural Statistics" were used where separate statistics were not available.

Source: Crop Reporting Board, Statistical Reporting Services, U.S. Department of Agriculture, 1982.

Appendix table 37.--Surface water resources

Water Resource Regions	Large water bodies(a) 1/	Reservoir area, storage, and evaporation(b): Pool surface area	Storage: Maximum 3/	Storage: Normal 4/	Net evaporation 5/: Estimated volume	Net evaporation 5/: Percent of mean flow	Natural outflow(b) 6/ (replenishable supply): Average year	Natural outflow(b) 6/ (replenishable supply): Dry year
			(million acre-feet)		(million ac-ft/yr)	(percent)	(billion gallons per day)	
1. New England	2,450	412	19.4	14.5	0	--	78.66	63.21
2. Mid-Atlantic	2,044	142	24.1	19.2	0	--	80.52	62.56
3. S. Atlantic-Gulf	7,068	1,766	60.7	41.1	0	--	232.54	168.67
4. Great Lakes	2,711	182	12.9	10.1	0	--	75.26	59.83
5. Ohio	994	681	43.3	15.8	0	--	139.00	106.90
6. Tennessee	721	466	23.7	11.0	0	--	41.11	36.21
7. Upper Mississippi	2,710	469	23.2	13.0	0.04	0.03	76.02	61.66
8. Lower Mississippi	2,923	542	19.6	6.2	0	--	75.02	15.41
9. Souris-Red-Rainy	1,316	18	7.5	4.4	0.01	0.18	6.14	3.49
10. Missouri	3,428	2,087	118.1	83.4	4.43	6.94	61.53	46.70
11. Ark.-White-Red	1,864	1,515	69.9	30.2	2.13	2.91	67.69	42.49
12. Texas-Gulf	2,490	930	55.0	25.5	1.44	3.79	35.63	19.62
13. Rio Grande	418	173	13.5	7.8	0.73	13.60	5.31	4.35
14. Upper Colorado	608	318	11.3	10.2	0.77	5.55	13.96	10.98
15. Lower Colorado	443	251	72.1	61.3	1.29	18.59	2.19	2.19
16. Great Basin	1,770	130	4.2	3.8	0.36	2.31	5.98	5.06
17. Pacific NW	2,575	1,280	65.2	54.7	2.14	0.72	268.52	226.59
18. California	1,665	413	44.2	39.0	0.72	0.89	68.05	50.44
Regions 1-18	38,198	11,775	688.0	449.3	14.07	1.11	1,330.33	986.35
19. Alaska		12	0.9	0.8	0	--		
20. Hawaii	29	7	0.1	0.1	0.01	0.01		
21. U.S. Caribbean	10	1	0.4	0.3	0	--		
TOTAL	38,237 2/	11,795	689.2	450.3	14.07	0.61		

1/ Large water bodies include streams one-eighth mile wide or wider and lakes of 40 acres or more. The Great Lakes, coastal waters, bays, and estuaries are not included.
2/ Exclusive of Alaska. In addition to large water bodies, total water resources include 5,451 million acres of streams less than 1/8 mile wide, 3,265 million acres of lakes 2-40 acres in size, and 1,402 million acres of ponds less than 2 acres.
3/ Maximum storage is flood capacity and normal storage.
4/ Normal storage is that capacity designated for purposes other than flood control.
5/ Zero values indicate that evaporation losses are offset by precipitation.
6/ Natural outflow is the long-range streamflow that would be available at the outflow point of a region if consumption were eliminated, ground water overdrafting were discontinued, water transfers ceased, and there were no net evaporative losses from reservoirs. The natural flow is a measure of replenishable supplies.

Sources: (a) Compiled from Statistical Abstract of the United States
(b) Second National Water Assessment

Appendix table 38.--Ground water resources

Water resource regions	Underground storage: Estimated total (a) volume	Underground storage: Available (b)1/	Underground storage: Recoverable volume of water (b)2/	Surface area overlying recoverable ground water (b)	Minimum recharge rate (a) 3/	Ground water withdrawals: Offstream uses (d): Nonagri. (c)	Ground water withdrawals: Offstream uses (d): Irrigation & livestock(c,d)	Ground water withdrawals: Overdraft in excess of recharge(a,d)
	----------(million acre-feet)---------			(million acres)	-----------(million acre-feet per year)-----------			
1 New England	N	N				0.72	0.01	
2 Mid-Atlantic	3,564	1,271				2.49	.22	0.1
3 South Atlantic	N	13,692				4.95	1.71	.4
4 Great Lakes	N	801				1.53	.36	.1
5 Ohio	4,295	1,176				2.60	.13	
6 Tennessee	N	1,627				.28	.02	
7 Upper Miss.	14,239	6,886				2.30	.75	
8 Lower Miss.	7,970	3,905			5.00	2.02	5.37	.5 - 2.4
9 S-R-R	2,158	528			.10	.06	.12	.1
10 Missouri	3,432	1,366	2,650	62.00	8.80	1.31	15.89	2.9 - 8.4
11 A-W-R	2,039	1,532	525	32.00	3.80	.94	8.28	5.4 - 6.1
12 Texas-Gulf	8,605	4,402	727	74.00	1.90	1.33	8.31	6.2 - 7.7
13 Rio Grande	49,221	5,753	4,151	6.10	1.90	.34	1.76	.2 - .7
14 Up. Colorado	3,236	240	-	.03	.14	.07	.25	.1 - .2
15 Lo. Colorado	1,753	N	1,028	8.70	2.90	.68	3.62	1.4 - 2.7
16 Great Basin	2,898	525	323	19.00	.94	.63	2.17	.7 - 1.9
17 C-N-P	4,227	553	264	25.00	7.50	3.42	8.67	.7 - 4.6
18 California	1,004	252	192	16.00	19.00	3.73	15.73	1.5 - 2.4
Contiguous U.S.						29.40	73.37	20.0 - 37.8
19 Alaska	N	3,443				.05	.01	
20 Hawaii	N	N				.36	.45	
21 U.S. Caribbean	N	49			.19	.20		
National Total						30.00	74.03	18.0 -37.8

1/ Portion of the total that can be tapped with conventional wells and methods.
2/ Available water that is suitable for irrigation and practical for withdrawal.
3/ Overdrafts are withdrawal rates that exceed ground water recharge rates. The recharge rate in subregions where there are no overdrafts is not known.

Sources: (a) Second National Water Assessment,Vol 3, Appendix II, Table II-1.
(b) Compiled by CARD from USGS Papers 813 and HA-648, Texas Department of Water Resources report 238, DOC 1978 Farm and Ranch Irrigation Census, Columbia-North Pacific Technical Staff paper - Appendix V, and DOC Six-State High Plains Ogallala Aquifer Regional Resources Study.
(c) USGS Circular 1001.
(d) 1985 RCA analysts.

Appendix table 39.--Summary of freshwater supply and use and additional water available for agriculture

Water resources region	Condition	Stream inflow	Supply: Natural outflow	Supply: Net import	Supply: Ground water overdraft 1/	Use: Consumption Non-ag.	Use: Consumption Ag.	Use: Net evapo.	Use: Net export	Remaining stream outflow	Instream flow req. 3/	Remaining additional water for ag.
		- million gallons per day -										
1. New England	1985 Ave	0	78,661	0	0	597	35	0	0	78,028	69,001	9,027
	2030 Ave	0	78,661	0	0	1,558	35	0	0	77,067	69,001	8,066
	Dry 5/	0	63,211	0	0	1,558	46	0	0	61,606	47,197	14,409
2. Mid-Atlantic	1985 Ave	0	80,522	479	32	2,134	226	0	0	78,672	68,840	9,832
	2030 Ave	0	80,522	479	32	4,610	226	0	0	76,196	68,840	7,356
	Dry	0	62,563	479	32	4,610	279	0	0	58,184	48,313	9,871
3. S.Atlantic-Gulf	1985 Ave	0	232,544	0	339	3,422	2,589	0	0	226,871	188,655	38,216
	2030 Ave	0	232,544	0	339	13,012	2,589	0	0	217,281	188,655	28,626
	Dry	0	168,668	0	339	13,012	3,866	0	0	152,128	139,526	12,602
4. Great Lakes	1985 Ave	0	75,262	19	27	3,046	401	0	0	71,860	63,951	7,909
	2030 Ave	0	75,262	19	27	7,218	401	0	0	67,688	63,951	3,737
	Dry	0	59,832	19	27	7,218	483	0	0	52,176	45,157	7,019
5. Ohio	1985 Ave	40,800	138,998	0	0	2,347	180	0	0	176,941	160,520	16,421*
	2030 Ave	39,027	138,998	0	0	7,257	180	0	0	170,567	160,520	10,047*
	Dry	34,126	106,898	0	0	7,257	224	0	0	133,520	107,681	25,838*
6. Tennessee	1985 Ave	0	41,113	0	0	601	40	0	0	40,471	38,480	1,991
	2030 Ave	0	41,113	0	0	2,065	40	0	0	39,007	38,480	527
	Dry	0	36,213	0	0	2,065	43	0	0	34,104	24,667	9,436
7. Upper Mississippi	1985 Ave	44,100	76,024	2,064	0	1,091	647	43	0	119,457	110,750	8,707*
	2030 Ave	41,231	76,024	2,064	0	3,422	647	46	0	114,193	110,750	3,443*
	Dry	24,447	61,664	2,064	0	3,422	817	46	0	82,726	71,505	11,220*
8. Lower Mississippi	1985 Ave	361,600	75,015	0	412	1,297	3,965	0	0	430,059	359,033	71,026*
	2030 Ave	343,663	75,015	0	412	4,380	3,965	0	0	410,141	359,033	51,108*
	Dry	249,101	15,405	0	412	4,380	4,433	0	0	255,336	241,897	13,438*
9. Souris- Red-Rainy	1985 Ave	0	6,138	0	0	55	129	16	0	5,937	3,673	2,264
	2030 Ave	0	6,138	641	0	89	129	19	0	6,541	3,673	2,868
	Dry	0	3,488	641	0	89	165	19	0	3,855	1,841	2,014
10. Missouri	1985 Ave	0	61,525	411	2,557	1,081	15,336	4,924	0	43,151	33,958	9,193
	2030 Ave	0	61,525	0	2,557	2,792	15,336	5,595	137	40,221	33,958	6,263
	Dry	0	46,695	0	2,557	2,792	17,444	5,595	137	23,283	18,457	4,825
11. Ark.-White-Red	1985 Ave	0	67,694	128	5,457	1,063	6,106	2,615	0	63,494	46,169	17,325
	2030 Ave	0	67,694	200	2,343	2,722	6,106	3,111	0	58,297	46,169	12,128
	Dry	0	42,494	200	2,343	2,722	7,118	3,111	0	32,085	20,308	11,777

Appendix table 39.--Summary of freshwater supply and use and additional water available for agriculture--continued

Water resources region	Condition	Stream inflow	Supply: Natural outflow	Supply: Net import	Supply: Ground water overdraft 1/	Use: Consumption Non-ag.	Use: Consumption Ag.	Use: Net evapo.	Use: Net export	Remaining stream outflow	Instream flow req. 3/	Remaining additional water for ag.
					- million gallons per day -							
12. Texas-Gulf	1985 Ave	0	35,626	30	5,578	2,433	6,282	1,705	0	30,813	22,917	7,896
	2030 Ave	0	35,626	30	3,245	8,585	6,282	1,992	0	22,041	22,917	-875
	Dry	0	19,622	30	3,245	8,585	7,090	1,992	0	5,229	10,687	-5,458
13. Rio Grande	1985 Ave	0	5,309	234	657	361	2,660	730	0	2,448	2,287	161
	2030 Ave	0	5,309	199	657	701	2,660	785	0	2,018	2,287	-268
	Dry	0	4,349	199	657	701	2,954	785	0	764	1,592	-828
14. Upper Colorado	1985 Ave	0	13,956	0	0	330	2,429	711	805	9,680	7,947	1,733
	2030 Ave	0	13,956	0	0	823	2,429	728	1,095	8,880	7,974	933
	Dry	0	10,976	0	0	823	2,687	728	1,095	5,642	4,186	1,455
15. Lower Colorado	1985 Ave	10,000	-605	0	2,415	739	3,044	1,202	4,463	2,041	6,864	-4,822*
	2030 Ave	8,921	-605	0	2,415	1,769	3,044	1,236	3,896	744	6,864	-6,119*
	Dry	5,708	2,185	0	2,415	1,769	3,133	1,236	3,896	208	2,904	-2,695*
16. Great Basin	1985 Ave	0	5,976	101	591	649	3,096	327	0	2,595	3,389	-793
	2030 Ave	0	5,976	251	591	1,205	3,096	333	0	2,183	3,389	-1,205
	Dry	0	5,060	251	591	1,205	3,493	333	0	870	1,792	-922
17. Pacific N.W.	1985 Ave	0	268,523	47	627	1,162	12,402	2,014	0	253,618	214,004	39,614
	2030 Ave	0	268,523	47	627	3,094	12,402	2,083	0	251,617	214,004	37,613
	Dry	0	226,586	47	627	3,094	15,655	2,083	0	206,427	80,556	125,871
18. California	1985 Ave	0	68,050	4,438	2,197	2,680	19,689	669	0	51,646	32,607	19,039
	2030 Ave	0	68,050	3,881	857	4,927	19,689	686	0	47,485	32,607	14,878
	Dry	0	50,442	3,881	857	4,927	21,180	686	0	28,386	20,415	7,971
Contiguous U.S. Regions 1-18	1985 Ave	0	1,330,331	2,677	20,889	25,088	79,263	14,956	0	1,234,589	1,035,221	199,936
	2030 Ave	0	1,330,331	2,677	14,102	70,229	79,263	16,614	0	1,181,003	1,035,221	145,782
	Dry	0	986,351	2,677	14,102	70,229	91,117	16,614	0	825,169	645,192	179,978

1/ Future (2030) overdrafts are limited to current (1975) or "allowable" overdrafts, whichever is the lesser. Allowable overdrafts are determined by dividing the stock resource (recoverable ground water) by 200 (to last 200 years).
2/ Irrigation water requirements for the dry year fully satisfy the crop requirement in 8 of 10 years.
3/ Instream-flow approximations (IFA) for fish and wildlife provide optimum habitat in average years. Instream-flow requirements for good survival habitat in dry years are assumed to be 60 percent of mean natural flow in the humid area (regions 1 through 8) and 30 percent of mean natural flow in the subhumid, semi-arid, and arid areas (regions 9 through 18) in dry years.
4/ Natural annual streamflows are exceeded 80 percent of the time.

*Volumes of water remaining for additional agriculture include surplus water from upstream regions.

Sources:
1975: Average condition from "The nation's water resources 1975-2000" (NWA) inflow and natural outflow - NWA, Vol. 3, Table II-5 for annual average; and
Appendix N, Table N-2 for annual dry condition. To column 17 (assessed total streamflow), add column 10 (net evaporation) and column 6 (net exports).
Future (2030) net imports, exports, and evaporation are NWA 2000 projections from Vol. 1, table on pages 54 and 55.
Recoverable water estimates from CARD memo dated 1/11/85.

Appendix table 40.--Irrigated area, irrigation water use efficiencies and volumes, by water resources region, 1982

Water resources region	Irrigated Area: Cropland, by source and system: Ground water: Pressure	Ground water: Gravity	Surface water: Pressure	Surface water: Gravity	Pasture	Total	Irrigated 1/ during 1982
	-----	-----	-----	thousand acres	-----	-----	-----
1. New England	3	1	39	4	1	47	34
2. Mid-Atlantic	145	2	140	13	7	309	242
3. South Atlantic	1,199	204	1,511	523	539	3,976	2,378
4. Great Lakes	366	3	257	24	4	654	462
5. Ohio	63	2	41	3	4	113	86
6. Tennessee	2	3	9	3	3	20	12
7. Upper Mississippi	684	14	93	13	1	804	646
8. Lower Mississippi	577	3,982	113	655	5	5,331	3,235
9. Souris-Red-Rainy	63	1	31	1	1	95	115
10. Missouri	5,155	3,511	823	3,450	828	13,768	11,575
11. Arkansas-White-Red	2,830	3,592	176	524	153	7,275	4,843
12. Texas-Gulf	2,320	3,303	99	782	99	6,604	3,583
13. Rio Grande	400	469	122	1,207	379	2,577	1,591
14. Upper Colorado	7	53	123	1,059	429	1,673	1,380
15. Lower Colorado	82	984	6	284	75	1,431	1,158
16. Great Basin	439	179	241	1,056	494	2,409	1,756
17. Pacific Northwest	2,140	353	2,218	2,320	1,426	8,458	6,995
18. California	2,413	1,983	1,371	3,330	933	10,029	8,631
Contiguous U.S.	18,877	18,637	7,413	15,250	5,380	65,570	48,719
19. Alaska					1	1	1
20. Hawaii	65	46	63	44	3	220	146
21. U.S. Caribbean	4	33	5	44	7	92	75
National Total	18,946	18,716	7,481	15,338	5,390	65,882	48,940

1/ Cropland and pastureland developed for irrigation as of 1982, according to 1982 National Resources Inventory.

Appendix table 40.--Irrigated area, irrigation water use efficiencies and volumes, by water resources region, 1982--continued

Water resources region	Irrigation water efficiencies				Water use	
	Off-farm conveyance efficiencies	Net depletion		Return flows	Withdrawals (Gross diversions)	Consumption (Net depletions)
		Crop & pasture	Incidental loss			
	--------Percent of gross diversions--------				1,000 acre-feet per year	
1. New England	96	65	5	30	31	21
2. Mid-Atlantic	96	65	5	30	266	184
3. South Atlantic	96	64	5	30	3,969	2,732
4. Great Lakes	96	65	5	30	527	365
5. Ohio	96	65	5	30	108	75
6. Tennessee	96	64	5	30	20	14
7. Upper Mississippi	96	68	7	25	601	441
8. Lower Mississippi	96	64	6	30	6,376	4,386
9. Souris-Red-Rainy	82	51	14	35	178	113
10. Missouri	82	49	14	37	27,359	16,673
11. Arkansas-White-Red	94	60	11	29	9,492	6,600
12. Texas-Gulf	93	60	11	29	9,885	6,844
13. Rio Grande	86	55	13	32	4,403	2,942
14. Upper Colorado	75	38	15	47	5,154	2,693
15. Lower Colorado	86	55	10	35	5,356	3,358
16. Great Basin	79	40	15	45	6,409	3,434
17. Pacific Northwest	73	36	14	50	28,800	13,804
18. California	76	53	13	35	34,625	21,938
Contiguous U.S.		49	13	38	143,561	86,617
19. Alaska						
20. Hawaii	75	50	8	42	938	538
21. U.S. Caribbean	74	48	12	40	467	261
National Total		48	13	39	144,966	87,416

Table 41.--Potentially irrigable land

		Land area, use, and characteristics								
		Land area		Cropland				Floodplain		
				Irrigated		Non-Irr.	Potential 1/ cropland	Cropland		Potential 1/ cropland
		Federal	Nonfederal	Gravity	Pres. & Gr.			Irr.	Non-Irr.	
		(million acres)								
1.	New England	1.18	40.55	.01	.05	2.42	1.91	.01	.18	.11
2.	Mid-Atlantic	2.60	61.20	.01	.29	11.68	5.79	.03	.78	.43
3.	South Atlantic	8.76	158.49	.29	3.15	23.08	25.06	1.14	2.74	5.03
4.	Great Lakes	6.72	76.60	.03	.63	24.68	6.94	.04	1.36	.40
5.	Ohio	4.06	97.35	.01	.11	32.34	10.61	.02	4.96	1.66
6.	Tennessee	2.83	23.70	.01	.02	3.58	3.47	.01	.91	.77
7.	Upper Mississippi	2.27	110.73	.02	.78	63.99	8.89	.06	6.62	1.34
8.	Lower Mississippi	2.61	60.87	4.24	1.08	17.90	6.47	2.04	9.05	2.54
9.	Souris-Red-Rainy	.64	33.03		.09	21.11	2.61	.01	1.70	.16
10.	Missouri	42.72	280.13	6.74	6.20	91.45	32.35	2.81	10.94	3.99
11.	Arkansas-White-Red	8.20	146.04	3.33	3.79	34.94	19.69	.77	4.74	2.84
12.	Texas-Gulf	2.16	108.81	3.67	2.84	17.67	14.55	.54	1.78	1.56
13.	Rio Grande	22.10	62.14	1.51	.69	.93	1.94	.54	.14	.33
14.	Upper Colorado	43.65	21.61	1.06	.19	.53	.51	.31	.02	.11
15.	Lower Colorado	51.16	50.47	1.26	.10	.03	2.35	.12	.01	.48
16.	Great Basin	66.08	21.37	1.19	.73	.96	7.06	.64	.08	.20
17.	Pacific Northwest	88.24	82.47	2.57	4.47	11.67	6.45	1.21	.89	1.08
18.	California	47.75	56.09	4.01	5.08	1.52	2.29	3.15	.27	.50
	Contiguous U.S.	403.73	1,491.65	29.92	30.26	360.37	152.59	13.45	47.16	23.52
19.	Hawaii			.09	.13	.12	.13	.04	.01	.01
20.	U.S. Caribbean			.08	.01	.32	.25	.06	.05	.05
	National Total			30.09	30.40	360.91	152.97	13.55	47.22	23.58

1/ Land with high and medium potential for conversion to cropland

Table 41.--Potentially irrigable land--continued

	Land area, use, and characteristics: Surface overlay ground water: Total	Dry cropland	Potential cropland	Additional acreage available	Available water supply: Recoverable ground water: Allowable	Overdraft	Remaining allowable overdraft	Remaining* additional for agr.	Use per acre	Additional acreage available	Net additional potential irrigable land
	(million acres)				million ac/ft				ac/ft	mill ac/ft	mill acres
1. New England				.29				8.81	.65	13.55	.29
2. Mid-Atlantic				1.21		.04		8.21	.83	9.89	1.21
3. South Atlantic				7.77		.38		13.74	1.51	9.10	7.77
4. Great Lakes				1.76		.03		4.45	.78	5.70	1.76
5. Ohio				6.62				11.38	.72	15.81	6.62
6. Tennessee				1.68				.61	.82	.75	.75
7. Upper Mississippi				7.96				5.52	.84	6.58	6.58
8. Lower Mississippi				11.59		.46		10.79	1.74	6.20	6.20
9. Souris-Red-Rainy				1.86				2.39	1.15	2.08	1.86
10. Missouri	62.24	18.12	6.41	24.53	13.25	2.86	10.39	6.60	1.64	10.36	10.36
11. Arkansas-White-Red	32.33	6.94	3.91	10.85	2.63	6.11	-3.48	11.89	1.66	7.16	7.16
12. Texas-Gulf	74.40*	11.47	9.45	20.92	3.64	6.25	-2.61	-6.34	2.19		
13. Rio Grande	6.12	.07	.14	.21	20.76	.73	20.03	-2.48	2.19		
14. Upper Colorado	.19							1.09	1.76	.62	
15. Lower Colorado	8.71	.01	.40	.41	5.14	2.70	2.44	-7.47	3.51		
16. Great Basin	19.39*	.58	4.25	4.83	1.62	.66	.96	-2.22	2.08		
17. Pacific NW	25.39	2.96	1.64	4.60	1.32	.70	.62	43.33	2.00	21.67	4.60
18. California	16.05	.30	.45	.75	.96	2.46	-1.50	3.12	3.12	1.0	.75
Contiguous U.S.				107.84					2.12	110.47	55.91
19. Hawaii											
20. U.S. Caribbean											
National Total											

* Remaining flows include the lesser of current or allowable overdraft of ground water.

Appendix table 42.--Storage required to obtain potential available dependable supply

Water resources region	Dependable annual streamflow		Storage required to meet potential		
	Current 1/	Potential 2/	Additional volume	Surface area	Initial cost
	(billion gallons per day)		(million acre-feet)	(thousand acres)	(billion 1984 dollars)
1. New England	62.7	63.3	17.5	635	13.6
2. Mid-Atlantic	70.4	73.5	23.0	547	25.8
3. South Atlantic-Gulf	164.1	182.5	10.6	3,589	55.4
4. Great Lakes	57.3	57.3	34.2	1,342	33.4
5. Ohio	257.8	263.2	65.9	3,224	70.8
6. Tennessee	55.2	55.3	18.3	787	13.7
7. Upper Mississippi	198.4	210.5(-.2)	48.0	2,345	35.9
8. Lower Mississippi	761.0	932.0	48.0	3,000	23.0
9. Souris-Red-Rainy	3.4	4.8	5.4	90	2.4
10. Missouri	99.2	107.2(-2.0)	31.5	1,591	23.5
11. Arkansas-White-Red	42.5	58.3(-2.1)	44.3	2,179	28.1
12. Texas Gulf	12.3	22.6(-1.5)	25.3	1,034	12.5
13. Rio Grande	.9	2.1(-.2)	1.3	43	.8
14. Upper Colorado	13.1	14.7(-.4)	4.8	138	4.4
15. Lower Colorado	1.6	1.6(-.1)	.3	11	.4
16. Great Basin	6.7	8.5(-.6)	5.6	220	12.4
17. Pacific Northwest	371.4	372.1(-2.3)	105.2	2,317	55.7
18. California	30.4	38.6(-.3)	34.7	787	47.0
Conterminous U.S./all	2,208.4	2,468.0(-9.7)	523.9	23,879	458.8
19. Alaska	795.0	795.0	202.8	3,379	607.5
20. Hawaii	4.9	5.4	4.5	90	13.5
21. Caribbean	3.3	3.9	3.3	82	4.9
United States and Caribbean	3,011.6	3,272.3(-9.7)	734.6	27,430	1,084.7

1/ Current annual streamflows are sums of "dry year" outflows (discharges with an 80 percent chance of being exceeded) of the aggregated subregions, as reported in the 1975 Second National Water Assessment (NWA).

2/ Potential streamflows are 80 percent of the sums of mean annual yields (outflows) of the aggregated subregions as reported in the NWA. Numbers in parentheses are the decrease in flows expected as a result of net evaporative losses.

Appendix table 43.--Flood-prone rural nonfederal land, by state and farming region

Farming region and state	Million acres	Farming region and state	Million acres
Northeast	6.8	Northern Plains	20.4
Connecticut	0.1	Kansas	6.2
Delaware	0.1	Nebraska	6.4
Maine	1.2	North Dakota	2.5
Maryland	0.6	South Dakota	5.2
Massachusetts	0.3		
New Hampshire	0.2	Southern Plains	26.0
New Jersey	0.7	Oklahoma	6.0
New York	2.0	Texas	20.0
Pennsylvania	1.4		
Rhode Island	0.05	Mountain	23.3
Vermont	0.2	Arizona	2.8
		Colorado	3.7
Lake States	10.5	Idaho	1.7
Michigan	1.4	Montana	4.0
Minnesota	3.2	Nevada	1.9
Wisconsin	5.9	New Mexico	4.0
		Utah	2.4
Corn Belt	21.9	Wyoming	2.8
Illinois	4.6		
Indiana	2.5	Pacific	11.3
Iowa	4.9	California	7.1
Missouri	8.1	Oregon	2.6
Ohio	1.8	Washington	1.6
Appalachia	15.8	Alaska	0.0
Kentucky	3.0	Hawaii	0.2
North Carolina	5.8	Caribbean	2.9
Tennessee	4.0		
Virginia	2.3		
West Virginia	0.7	TOTAL	197.3
Southeast	30.5		
Alabama	5.7		
Florida	14.2		
Georgia	7.7		
South Carolina	2.9		
Delta States	27.9		
Arkansas	6.9		
Louisiana	11.5		
Mississippi	9.6		

Source: 1982 National Resources Inventory.

Appendix table 44.--Nonfederal wetlands, Cowardin et al. classification (1979)

Region and state	Wetland system type				
	Marine	Estuarine	Riverine	Lacustrine	Palustrine
	(acres)				
NORTHEAST					
Connecticut	-	12,200	-	800	304,200
Delaware	-	86,500	-	-	152,600
Maine	-	16,800	-	2,700	1,970,300
Maryland	-	192,900	-	1,500	744,500
Massachusetts	3,000	43,800	-	1,700	455,600
New Hampshire	-	-	-	-	227,800
New Jersey	-	208,900	-	3,500	332,900
New York	3,500	8,400	500	34,300	2,459,300
Pennsylvania	-	-	-	4,500	664,900
Rhode Island	200	5,000	-	300	77,400
Vermont	-	-	-	1,800	181,000
Region	6,700	574,500	500	51,100	7,570,500
APPALACHIA					
Kentucky	-	-	-	-	324,300
North Carolina	-	127,600	-	19,300	2,758,800
Tennessee	-	-	-	-	856,600
Virginia	-	176,700	-	-	1,105,000
West Virginia	-	-	-	400	32,600
Region	-	304,300	-	19,700	5,077,300
SOUTHEAST					
Alabama	-	9,500	-	-	3,792,800
Florida	5,000	693,800	-	373,400	6,735,000
Georgia	-	377,400	-	-	4,778,900
South Carolina	2,200	382,200	-	-	3,109,300
Region	7,200	1,462,900	-	373,400	18,416,000
LAKE STATES					
Michigan	-	6,200	-	51,300	4,032,900
Minnesota	-	-	-	135,600	7,632,100
Wisconsin	-	2,100	-	119,000	5,118,400
Region	-	8,300	-	305,900	16,783,400
CORN BELT					
Illinois	-	-	3,100	5,600	863,100
Indiana	-	-	1,300	7,500	229,100
Iowa	-	-	-	7,700	126,200
Missouri	2,400	-	-	2,600	112,400
Ohio	-	-	-	1,000	849,000
Region	2,400	-	4,400	24,400	2,179,800
DELTA STATES					
Arkansas	-	-	2,500	-	1,329,600
Louisiana	-	2,878,700	-	-	3,211,600
Mississippi	-	25,300	1,400	-	2,839,700
Region	-	2,904,000	3,900	-	7,380,900
NORTHERN PLAINS					
Kansas	-	-	-	3,000	25,700
Nebraska	-	-	-	4,900	1,031,600
North Dakota	-	-	-	2,400	2,905,500
South Dakota	-	-	-	4,700	1,526,400
Region	-	-	-	15,000	5,489,200

Appendix table 44.--Nonfederal wetlands, Cowardin et al. classification (1979)--continued

Region and state	Wetland system type				
	Marine	Estuarine	Riverine	Lacustrine	Palustrine
	(acres)				
SOUTHERN PLAINS					
Oklahoma	-	-	1,000	-	148,600
Texas	8,100	466,400	22,000	25,900	2,429,500
Region	8,100	466,400	23,000	25,900	2,578,100
MOUNTAIN					
Arizona	-	-	-	-	134,900
Colorado	-	1,600	2,000	1,500	486,900
Idaho	-	-	7,400	12,900	420,800
Montana	-	-	31,700	37,100	788,900
Nevada	-	100	-	24,300	107,300
New Mexico	-	-	400	6,400	57,300
Utah	-	1,500	2,000	510,600	581,500
Wyoming	-	87,600	600	6,500	263,300
Region	-	90,800	44,100	599,300	2,840,900
PACIFIC					
California	-	125,200	58,100	88,000	1,134,500
Oregon	3,300	10,800	9,600	-	762,500
Washington	-	8,900	-	600	437,300
Region	3,300	144,900	67,700	88,600	2,334,300
OTHER					
Hawaii	-	-	-	4,500	62,100
Puerto Rico	-	28,700	-	-	9,300
Region	-	28,700	-	4,500	71,400
TOTAL	27,700	5,984,800	143,600	1,507,800	70,721,800

The Marine system consists of the open ocean overlying the continental shelf and the associated high-energy coastline. Shallow bays without significant freshwater inflow and coasts with exposed rocky islands that provide the mainland little shelter from wind and waves are also considered Marine systems.

The Estuarine system consists of deepwater tidal habitats and adjacent tidal wetlands that are generally semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land.

The Riverine system includes all wetlands and deepwater habitats contained within a channel, except wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and habitats with water containing ocean-derived salts in excess of 0.5 °/₀₀.

The Lacustrine system includes wetlands and deepwater habitats that are situated in a depression or dammed river channel; do not have more than 30 percent of their area covered with trees, shrubs, persistent emergents, emergent mosses or lichens; and have a total area greater than 20 acres. Similar habitats of less than 20 acres are also included if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 6.6 feet at low water.

The Palustrine system includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands in tidal areas where salinity due to ocean-derived salts is below 0.5°/₀₀. It also includes wetlands that are not dominated by such vegetation but are less than 20 acres, do not have active wave-formed or bedrock shoreline features, have a water depth in the deepest part of the basin of less than 6.6 feet at low water, and have salinity due to ocean-derived salts less than 0.5°/₀₀.

Source: 1982 National Resources Inventory.

Appendix table 45.--Acreage of nonfederal wetlands, by vegetative cover Circular 39 classification

Wetland 1/ Type	Description	Vegetative cover Crop	Pasture	Range	Forest	Other 2/	Total
		(million acres)					
1&2	Seasonally flooded basins or flats and waterlogged meadows	3.7	4.3	3.6	17.8	2.2	31.7
3-8	Freshwater marshes, swamps, or bogs	0.2	1.0	1.9	23.9	9.5	36.4
9-11	Inland saline flats, marshes, or open areas	0.1	0.1	0.6	.1	1.1	1.9
12-20	Coastal flats, salt meadows, marshes swamps, and open water	0.0	.1	0.6	.1	5.5	6.2
All nonfederal wetlands in Types 1-20		4.0	5.4	6.7	41.8	18.3	76.2

1/ Types as defined in Shaw and Fredine, Circular 39, Fish and Wildlife Service, USDI.
2/ "Other" is a residual category that includes refuges and parks.

Source: 1982 National Resources Inventory.

Appendix table 46.--Acreage of nonfederal wetlands, by farming region. Circular 39 classification

Farming region	Wetland type 1-2	3-8	9-20	Total 1-20
	(million acres)			
Northeast	2.39	4.83	0.64	7.86
Lake States	2.40	14.28	.01	16.68
Corn Belt	1.72	.38	.01	2.11
Northern Plains	3.04	1.80	.38	5.21
Appalachia	2.43	2.45	.37	5.25
Southeast	8.25	10.04	1.62	19.90
Delta States	5.71	1.65	2.88	10.23
Southern Plains	2.08	.21	.66	2.94
Mountain	1.95	.26	1.12	3.33
Pacific	1.75	.50	.32	2.57
Hawaii & Puerto Rico	.01	.07	.03	.11
United States	31.71	36.45	8.03	76.19

Source: 1982 National Resources Inventory.

Appendix table 47.--Wetland having high and medium potential for conversion to cropland

Farming region	Acreage
	(thousand acres)
Northeast	469
Appalachia	567
Southeast	1,288
Lake States	742
Corn Belt	371
Delta States	546
Northern Plains	553
Southern Plains	124
Mountain	205
Pacific	320
Contiguous U.S.	5,185

Source: 1982 National Resources Inventory.

Table 48.--Population, gross national product, and disposable personal income in the United States, projections to 2030

Year	Population		Gross national product		Per capita gross national product		Disposable personal income		Per capita disposable personal income	
	Million	Annual rate of Change	Billion 1972 dollars	Annual rate of change	1972 dollars	Annual rate of change	Billion 1972 dollars	Annual rate of change	1972 dollars	Annual rate of change
1990	249.7	.9	1,970	3.4	7,890	2.4	1,380	3.4	5,530	2.4
2000	268.0	.7	2,580	2.7	9,630	2.0	1,800	2.7	6,720	2.0
2010	283.1	.5	3,310	2.5	11,690	2.0	2,310	2.5	8,160	2.0
2020	296.3	.5	4,070	2.1	13,740	1.6	2,840	2.1	9,580	1.6
2030	304.3	.3	5,050	2.2	16,600	1.9	3,520	2.2	11,570	1.9

Sources:
Population: U.S. Department of Commerce, Bureau of the Census. Curr. Pop. Reps. Ser. P-25. Projections of the population of the United States: 1982 to 2050 (advance report).
Gross national product: U.S. Department of Commerce, Bureau of Economic Analysis. 1980 OBERS BEA regional projections, vol. 1: methodology, concepts, and state data. July 1981.
Disposable personal income: U.S. Department of Agriculture, Forest Service and Soil Conservation Service.

Table 49.--Export demand, actual and projected

Commodity	1980 1/	1990 2/	2000 2/	2030 2/
	(million bushels)			
Moderate level				
Wheat	1,510.0	1,798.0	2,316.4	4,275.4
Soybeans	724.3	1,057.7	1,642.5	3,720.3
Corn	2,355.0	2,876.0	4,203.9	8,190.0
Grain sorghum	299.0	268.0	296.3	718.0
Oats	13.0	10.1	12.5	18.2
Barley	77.0	60.1	78.6	111.6
Intermediate level				
Wheat	1,510.0	1,474.1	1,779.4	2,809.6
Soybeans	724.3	930.0	1,285.0	2,355.0
Corn	2,355.0	2,450.0	3,245.0	5,333.0
Grain sorghum	299.0	221.9	281.4	461.5
Oats	13.0	4.6	5.4	7.1
Barley	77.0	40.0	49.0	65.0

1/ Source: Agricultural Statistics.
2/ Source: Economic Research Service.

Table 50.--Projected annual rates of increase in yield for 11 major crops

	Feedgrains*	Alfalfa	Wheat	Cotton	Rice	Soybeans
			Percent			
Most probable:						
1982-2000	1.887	1.018	2.278	1.013	3.926	2.646
2001-2030	1.196	0.746	0.964	0.964	0.746	1.067
High:						
1982-2000	2.646	2.086	3.158	1.887	5.222	4.478
2001-2030	1.499	1.242	1.196	0.649	0.610	0.807
Optimistic:						
1982-2000	3.926	2.646	3.926	3.926	6.294	5.222
2001-2030	1.361	1.499	1.361	1.361	0.515	1.579
Low:						
1982-2000	1.018	0.531	1.247	0.0	2.278	1.468
2001-2030	0.746	0.427	0.610	0.606	0.964	0.695

*Feedgrains consist of barley, corn, corn silage, oats, sorghum and sorghum silage.

Source: Future Agricultural Technology and Resource Conservation, Iowa State University Press, 1984.

Table 51.--Projected increase in efficiency of producing foods of animal origin by the years 2000 and 2030

Animal/product	Unit	2000	2030
		(Percent)	
Beef	Liveweight marketed per breeding female	1.389	1.167
Pork	Liveweight marketed per breeding female	1.944	0.833
Dairy	Milk marketed per breeding female	1.667	1.167
Sheep	Liveweight marketed per breeding female	1.944	1.167
Broiler chickens	Liveweight marketed per breeding female	1.667	0.167
Turkeys	Liveweight marketed per breeding female	2.222	0.
Laying hens	Number of eggs	1.111	0.167
Fish (Catfish)	Age to market weight (one pound)	2.778	5.0

Source: Future Agricultural Technology and Resource Conservation, Iowa State University Press, 1984.

Table 52.--Projected acreage in nonagricultural uses, 1982-2030

Farming region and state	1982	Projected 1990	Projected 2000	Projected 2030	Projected change from 1982: 1990	Projected change from 1982: 2000	Projected change from 1982: 2030
	1,000 acres						
NORTHEAST							
Maine	857	976	1,111	1,450	119	254	593
New Hampshire	425	561	741	1,324	136	316	899
Vermont	375	392	413	467	17	38	92
Massachusetts	1,619	1,715	1,782	1,727	96	163	108
Rhode Island	231	246	259	263	15	28	32
Connecticut	1,046	1,110	1,160	1,168	64	114	122
New York	3,404	3,585	3,699	3,514	181	295	110
New Jersey	1,794	1,921	2,030	2,132	127	236	338
Pennsylvania	5,564	5,718	5,814	5,639	154	250	75
Delaware	294	311	329	365	17	35	71
Maryland	1,485	1,609	1,735	1,976	124	250	491
District of Columbia	39	39	39	39	0	0	0
Region	17,133	18,183	19,110	20,065	1,050	1,977	2,932
LAKE STATES							
Michigan	6,411	6,528	6,592	6,423	117	181	12
Wisconsin	5,260	5,400	5,541	5,789	140	281	529
Minnesota	7,426	7,620	7,813	8,138	194	387	712
Region	19,097	19,548	19,946	20,350	451	849	1,252
CORN BELT							
Ohio	5,417	5,634	5,805	5,813	217	388	396
Indiana	3,469	3,614	3,754	3,971	145	285	502
Illinois	4,333	4,536	4,708	4,816	203	375	483
Iowa	3,141	3,235	3,322	3,435	94	181	294
Missouri	4,047	4,198	4,343	4,571	151	296	524
Region	20,407	21,217	21,933	22,606	810	1,526	2,199
NORTHERN PLAINS							
North Dakota	2,863	2,880	2,898	2,933	17	35	69
South Dakota	2,571	2,590	2,610	2,652	19	39	81
Nebraska	2,396	2,442	2,492	2,606	46	96	210
Kansas	3,140	3,238	3,342	3,580	97	202	440
Region	10,970	11,150	11,342	11,770	180	372	800
APPALACHIA							
Virginia	2,847	3,206	3,636	4,921	359	789	2,074
West Virginia	1,595	1,647	1,706	1,853	52	111	258
North Carolina	3,485	3,832	4,245	5,462	347	760	1,977
Kentucky	2,819	2,999	3,217	3,890	180	398	1,071
Tennessee	3,202	3,581	4,031	5,357	379	829	2,155
Region	13,948	15,264	16,835	21,482	1,316	2,887	7,534
SOUTHEAST							
South Carolina	2,355	2,584	2,864	3,724	229	509	1,369
Georgia	3,096	3,526	4,046	5,625	430	950	2,529
Florida	5,705	6,963	8,604	13,745	1,258	2,899	8,040
Alabama	3,121	3,503	3,944	5,153	382	823	2,032
Region	14,277	16,576	19,458	28,247	2,299	5,181	13,970
DELTA STATES							
Mississippi	2,107	2,260	2,441	2,958	153	334	851
Arkansas	2,550	2,730	2,950	3,628	180	400	1,078
Louisiana	4,953	5,180	5,456	6,288	227	503	1,335
Region	9,610	10,170	10,846	12,874	560	1,236	3,264

Table 52.--Projected acreage in nonagricultural uses, 1982-2030--continued

Farming region and state	1982	Projected 1990	Projected 2000	Projected 2030	Projected change from 1982: 1990	Projected change from 1982: 2000	Projected change from 1982: 2030
	1,000 acres						
SOUTHERN PLAINS							
Oklahoma	3,474	3,861	4,346	5,918	387	872	2,444
Texas	12,828	14,448	16,575	23,914	1,620	3,747	11,086
Region	16,302	18,309	20,922	29,832	2,007	4,620	13,530
MOUNTAIN							
Montana	3,035	3,058	3,058	3,154	23	50	119
Idaho	1,637	1,723	1,855	2,411	86	218	774
Wyoming	2,194	2,298	2,485	3,431	104	291	1,237
Colorado	3,791	4,113	4,607	6,631	322	816	2,840
New Mexico	5,901	6,011	6,160	6,657	110	259	756
Arizona	5,115	6,034	7,599	14,559	919	2,484	9,444
Utah	2,115	2,477	3,082	5,817	362	967	3,702
Nevada	1,260	1,609	2,260	5,633	349	1,000	4,373
Region	25,048	27,324	31,133	48,293	2,276	6,085	23,245
PACIFIC							
Washington	4,308	4,480	4,693	5,327	172	385	1,019
Oregon	1,782	1,895	2,040	2,490	113	258	708
California	9,136	9,767	10,511	12,537	631	1,375	3,401
Region	15,226	16,142	17,244	20,353	916	2,018	5,127
48 states	162,018	173,882	188,769	235,872	11,864	26,751	73,854
Alaska	70,008	70,082	70,177	70,480	74	169	472
Hawaii	1,358	1,386	1,420	1,514	28	62	156
United States	233,384	245,350	260,367	307,865	11,966	26,983	74,481

"Nonagricultural" land includes urban land, farmsteads, small built-up areas, stripmines, borrow pits, gravel pits, quarries, permanent ice and snow, plus any other land not usable for agriculture or forestry purposes.

Source: National Interregional Agricultural Projections system.

Table 53.--Alternative futures, intermediate and high and low stress

		Intermediate future			High stress	Low stress
		1990	2000	2030	2030	2030
Cropland available	mil ac	370.4	364.0	346.9	347.3	354.8
Cropland used	mil ac	289.9	218.3	218.4	345.8	160.6
Irrigation water						
Major crops (net depletion)						
Surface	mil ac-ft	19.0	15.5	9.3	16.0	3.9
Ground	mil ac-ft	36.0	13.2	14.9	61.6	7.2
Subtotal	mil ac-ft	55.0	28.7	24.2	77.6	11.1
Other crops	mil ac-ft	23.6	23.7	22.5	22.5	22.5
Total	mil ac-ft	78.6	52.4	46.7	100.1	33.6
Crop yields						
Corn	bu/ac	122.8	158.3	197.7	184.0	266.1
Soybeans	bu/ac	44.1	56.9	68.7	69.8	103.4
Wheat	bu/ac	45.0	60.9	69.8	65.8	101.2
Crop production						
Corn	mil bu	7,232.6	7,755.8	9,917.0	16,984.1	9,274.7
Soybeans	mil bu	2,240.0	2,744.3	4,150.0	6,552.9	3,974.3
Wheat	mil bu	2,528.0	2,562.7	3,674.7	6,374.7	3,386.8
Tillage						
Conventional	mil ac	127.0	45.0	16.8	74.7	11.6
w/o winter cover		33.3	11.5	1.8	23.6	2.3
w/ winter cover		93.7	33.5	15.0	51.1	9.3
Conservation	mil ac	118.9	123.1	143.9	217.9	95.9
No-till	mil ac	15.9	23.1	33.5	29.0	29.0
Erosion rates						
Sheet & rill (USLE)	ton/ac	3.1	2.7	2.3	4.2	2.1
Wind	ton/ac	3.8	1.9	1.4	3.4	2.1
Total erosion						
Sheet & rill	mil ton	807.0	512.2	480.0	1,439.2	254.3
Wind	mil ton	1,002.9	356.4	296.4	1,159.2	286.4
Distribution of cropland by erosion rate:						
≤2.49	percent	26.7	36.5	42.1	24.2	41.9
2.5-4.99	percent	36.4	44.6	46.4	22.7	45.3
5.0-9.99	percent	17.2	9.7	6.2	28.5	7.1
10.0-24.99	percent	17.3	8.1	4.6	20.8	4.1
≥25.0	percent	2.4	1.1	0.7	3.8	1.6
Livestock production:						
Beef	mil cwt	413.6	443.5	533.3	540.1	533.3
Pork	mil cwt	228.4	233.5	263.8	265.4	263.8
Dairy	mil cwt	1,344.6	1,328.3	1,553.7	1,559.9	1,553.7

Table 53.--Alternative futures, intermediate and high and low stress--continued

		Intermediate future 1990	2000	2030	High stress 2030	Low stress 2030
Cost of production						
Crops						
Fertilizer	mil $	5,633.0	5,856.9	7,745.0	12,805.8	6,388.5
Pesticides	mil $	3,513.2	2,957.2	3,489.8	5,700.3	2,271.0
Machinery	mil $	5,076.2	3,679.2	3,677.2	6,699.9	2,452.1
Labor	mil $	2,206.9	1,589.0	1,595.7	2,837.0	1,061.5
Water	mil $	1,358.0	760.8	893.4	2,631.2	296.1
Other	mil $	12,670.5	9,832.8	10,343.8	17,909.0	6,852.8
Total crops	mil $	30,457.8	24,675.9	27,744.9	48,583.2	19,422.0
Livestock						
Mach & equip	mil $	6,492.0	6,321.8	6,595.9	6,788.4	6,500.2
Labor	mil $	3,866.5	3,548.7	3,567.9	3,844.0	3,510.5
Other	mil $	8,641.8	8,351.5	8,471.1	8,663.3	8,453.9
Total lvstk	mil $	19,000.3	18,222.0	18,634.9	19,295.7	18,464.6
Transportation	mil $	3,561.5	4,276.7	5,645.1	10,165.6	4,980.3
Total cost	mil $	53,109.6	47,174.6	52,024.9	78,044.5	42,866.9
Fertilizer use						
Per acre:						
N	lb/ac	55	74	88	94	107
P	lb/ac	29	40	52	51	58
K	lb/ac	20	27	33	33	40
Total:						
N	mil ton	8.0	8.1	10.0	17.1	8.7
P(205)	mil ton	4.1	4.3	5.9	9.3	4.7
K(20)	mil ton	2.9	3.0	3.8	6.1	3.2
Energy use						
Crop	trl btu	832.2	694.2	812.6	1,573.9	638.0
Livestock	trl btu	169.2	169.5	183.0	194.4	180.9
Total	trl btu	1,001.4	863.7	995.6	1,768.3	818.9

Source: CARD/RCA linear programming model. Cost estimates are in constant 1982 dollars.

Appendix table 54.--Projected production of grain-fed and roughage-fed beef

	1982	2030			
		Low stress	Intermediate		High stress
			with FSA	without FSA	
	(million cwt)				
Northeast	7.5	18.9	17.7	18.8	16
Appalachia	7.9	42.2	41.2	46.2	33
Southeast	2.5	9.6	12.6	12.7	7.1
Lake States	63.7	22.7	31.4	27.2	3.7
Corn Belt	102.6	121.8	109.2	130.9	67.2
Delta	4.6	33.2	39.9	48.9	7.1
Northern Plains	36.1	67.1	65.6	64.5	78.6
Southern Plains	82.9	108.3	113.6	82.2	149.8
Mountain States	42.6	42.5	37.5	40	88
Pacific States	23	67.1	64.6	61.9	89.7
Total	373	533	533	533	540

Source: CARD/RCA model.

Appendix table 55.--Projected production of feeder cattle

	1982	2030			
		Low stress	Intermediate		High stress
			with FSA	without FSA	
	(million cwt)				
Northeast	1.1	1	1	1	1.1
Appalachia	7.6	26	15.1	28.1	1.7
Southeast	.3	7.8	16.1	12.9	3.9
Lake States	1.7	.5	1.9	.5	1.6
Corn Belt	21.1	34.6	20.6	51.1	2.4
Delta	10.5	31.3	27.7	36.8	9.2
Northern Plains	15.3	13.1	17.3	8.7	24.2
Southern Plains	64.7	60.6	71.3	44.2	86.6
Mountain States	11.3	18.5	22.2	18.2	39.8
Pacific States	5.3	40.3	42.2	30.8	69.8
Total	139	234	233	232	240

Source: CARD/RCA model.

Appendix table 56.--Projected use of agricultural products, First and Second RCA Appraisals

Projection year		2000		2030	
Appraisal		RCA 1	RCA 2	RCA 1	RCA 2
POPULATION (millions)		260.4	268.0	300.3	304.3
DOMESTIC (pounds per capita)					
Beef and veal		140.0	110.4	152.0	110.9
Pork		70.0	64.0	74.0	62.8
Lamb		1.4	1.9	1.2	2.0
Chicken		65.0	59.6	58.0	60.1
Turkey		11.7	11.5	13.9	12.7
Milk		529.0	511.2	549.3	516.1
Eggs		33.0	29.8	30.0	31.0
Wheat		158.0	156.5	173.0	146.6
Rice		14.2	26.8	15.3	30.6
Corn		126.0	67.5	140.0	61.0
Peanuts		11.0	10.3	11.4	10.4
Irish potatoes		134.0	131.3	140.0	145.9
Dry beans and peas		5.3	5.9	4.3	5.7
Noncitrus fruit		109.0	121.1	115.0	133.8
Citrus fruit		139.0	140.1	145.0	150.2
Sugar		95.0	63.2	94.0	63.6
Vegetables and melons		273.0	275.4	290.0	298.3
Cotton		14.0	8.5	13.4	5.0
FEED USE	(millions)				
Barley	bu	310.0	241.8	357.2	215.7
Corn	bu	4,766.0	2,495.0	5,413.0	2,458.0
Legume hay	ton	90.8	48.6	103.8	18.2
Nonlegume hay	ton	63.4	11.6	73.6	8.6
Oats	bu	688.2	11.1	762.5	0.0
Silage	ton	123.7	41.6	133.6	40.5
Sorghum	bu	974.6	1,372.9	1,130.8	1,554.3
Soybeans	bu	831.3	1,198.6	927.7	1,391.5
Wheat	bu	226.8	0.0	259.1	0.0
EXPORTS	(millions)				
Wheat	bu	1,999	1,779	2,411	2,810
Rice	cwt	188	35	208	50
Soybeans	bu	1,436	1,285	1,866	2,355
Corn	bu	2,520	3,245	3,229	5,333
Sorghum	bu	322	281	413	462
Oats	bu	21	5	26	7
Barley	bu	79	49	101	65
AVERAGE YIELDS (units per acre)					
Corn	bu	107.0	158.3	144.0	197.7
Wheat	bu	35.0	60.9	42.0	69.8
Soybeans	bu	36.0	56.9	44.0	68.7
Cotton	bale	1.1	1.9	1.4	1.9
Sorghum	bu	57.0	97.9	67.0	126.8
Legume hay	tons	3.2	4.4	3.8	4.2
CROPLAND NEEDS (million acres)		385.9	218.3	388.8	218.5

First Appraisal central case.
Second Appraisal, intermediate scenario with Food Security Act included.

Source: CARD/RCA model.

Table 57.--National average yield projections, First and Second RCA Appraisals

Crop	Units	2000 RCA1	2000 RCA2	Increase (percent)	2030 RCA1	2030 RCA2	Increase (percent)
Barley	bushel	53	79	50	58	88	52
Corn	bushel	107	158	48	144	198	38
Corn silage	ton	14	22	62	15	27	74
Cotton	bale	1.1	1.9	73	1.4	1.9	36
Legume hay	ton	3.2	4.4	38	3.8	4.2	11
Oats	bushel	64	69	8	68	86	26
Sorghum	bushel	57	98	73	67	127	89
Sorghum silage	ton	15	17	18	14	19	39
Soybeans	bushel	36	57	60	45	69	54
Wheat	bushel	35	61	72	42	70	65

Source: CARD/RCA model.

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